Mornington - Marion Downs - Tableland Wildlife Sanctuaries

Ecohealth Report 2020





australian wildlife conservancy

Summary

Australian Wildlife Conservancy (AWC) has implemented an Ecological Health Monitoring program to measure the changes in ecological health across Mornington, Marion Downs, and Tableland Sanctuaries. Metrics from the program are reported in annual Ecohealth Reports and Scorecards. This is the 2020 Ecohealth Report for Mornington, Marion Downs, and Tableland Wildlife Sanctuaries (MMDT). Values and metrics outlined in this report were based on data collected during surveys carried out between 2004-2020. The complete set of metrics and their most recent values are summarised in the accompanying Ecohealth Scorecard.

In total, 11,129 camera trap nights, 385 live-trap nights, 66 km of spotlight transects and 886 km of aerial surveys were conducted as part of MMDT Ecohealth surveys in 2020. Additionally, targeted monitoring of Northern Quoll (*Dasyurus hallucatus*) and Purple-crowned Fairywren (*Malurus coronatus*) continued, with standardised monitoring programs for Northern Brown/Golden Bandicoot (*Isoodon macrourus/auratus*) and Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*) established.

Drought conditions, with below-average rainfall in the 2019-20 wet season (551 mm) following one of the driest wet seasons on record in 2018-19 (404 mm), are likely to be a key driver in patterns of abundance and occupancy detected on surveys across MMDT in 2020. In particular, the population estimate for Purple-crowned Fairywren has declined by 55% since the 2018-19 wet season, with a wildfire also affecting the focal popuation.

Additionally, the arrival of cane toads on MMDT in 2016-17 caused a dramatic decline in the abundance and occupancy of native predators, particularly the Northern Quol and large reptile guilds (Freshwater Crocodile, goannas and Blue-tongue Skinks).

A new survey method for aerial herbivore surveys was conducted in 2020 to obtain an accurate population estimate of feral herbvivores across MMDT. In 2020, an estimate of 16,270 cattle was generated, primarily within 2 km of water in the late dry season, directing intensive and targeted land management efforts for destocking MMDT 2021.

For several indicators, results from surveys in previous years (2004-2018) provide baseline numbers for comparison. For others, 2020 was the first year of survey, or methods remain in development. The dry conditions of the 2018-19 and 2019-20 wet seasons and subsequent low detection rates indicate that caution should be exercised when establishing baseline numbers from 2019 and 2020. Further data collection over the next few years will be important for teasing out the changes in abundance and occupancy of wildlife from climatic effects and the impact of cane toads. An above average wet season is predicted for 2020-2021 and the future surveys will provide valuable data on the ecological condition following two dry years as well as important direction for the development of future land management to optimise the outcomes for MMDT's native wildlife.

Contents

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Cover photographs: Clockwise from top left- Gouldian Finch, Common Rock-rat, Purple-crowned Fairywren, Northern Quoll, Boab and fire on Mornington – Marion Downs – Tableland Wildlife Sanctuaries, Kimberley, WA.

Introduction

Australian Wildlife Conservancy (AWC) owns, manages or works in partnership across 30 properties in Australia, covering almost 6.5 million hectares, to implement our mission: *the effective conservation of Australian wildlife and their habitats*. AWC relies on information provided by an integrated program of monitoring and research to measure progress in meeting its mission and to improve conservation management. AWC's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes and threats on each of these properties (Kanowski et al. 2018). The program focuses on selected 'indicator' species, guilds, processes and threats using metrics derived from data collected through a series of purpose-designed surveys.

The structure of the Ecohealth Program on each AWC property is as follows. Based on guidance provided by AWC's over-arching program framework, above, Ecohealth Monitoring Plans are developed, describing the conservation values or assets of each property, and threats to these assets; and setting out the monitoring program that will be used to track the status and trend of selected indicators of these conservation assets and threats. Annual survey plans and schedules are developed to implement these plans. The outcomes of these surveys are presented in annual Ecohealth Reports and summary Ecohealth Scorecards.

This document is the first in the series of annual Ecohealth Reports for Mornington, Marion Downs, and Tableland Wildlife Sanctuaries (referred to here as MMDT). It draws on surveys (Porter 2020; Riles 2020; Stockwell 2020a; 2020b) conducted during 2020 to report on the status and trends of the Ecohealth indicators. The companion Ecohealth Scorecard presents these metrics in a summary format.

Mornington, Marion Downs Wildlife Sanctuaries and Tableland Partnership Area

The Mornington, Marion Downs Wildlife Sanctuaries and Tableland Partnership Area (MMDT) are located in the Central Kimberley (Figure 1).

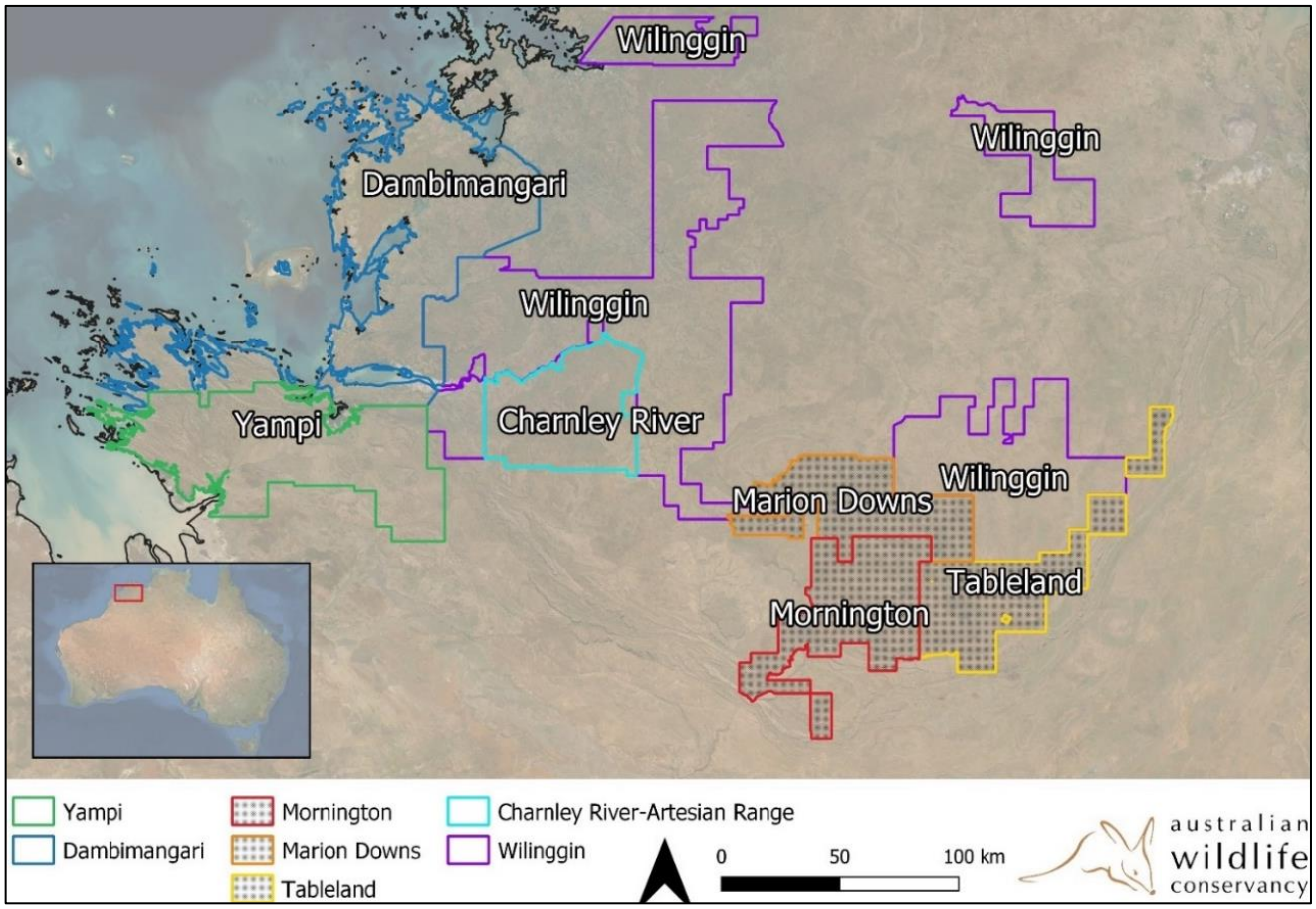

Figure 1. Location of Mornington, Marion Downs Wildlife Sanctuaries and Tableland and Partnership Area (MMDT) in the Central Kimberley region. Other AWC sanctuaries (MMDT, Charnely River) and partnership areas (Wilinggin, Dambimangari and Yampi) shown for context.

The Central Kimberley Bioregion encompasses the lower half of the Kimberley Basin, an ancient landscape created by marine sedimentation and volcanic activity almost two billion years ago, and the subsequent buckling and folding of these rocks units as the Kimberley plate collided with the Northern Australian plate. This tectonic activity formed the spectacular Wunaamin Miliwundi Ranges in the south of the bioregion.

The long and varied geological history of the Central Kimberley has resulted in a complex patterning of soils, which support a diverse array of woodlands and savannas. Combined with this, a north-south rainfall gradient (from 900 mm/year to 500 mm/year) drives a general cline of vegetation from taller open woodlands in the north, to very sparse, low savannas at the southern edge of the bioregion, just before the transition to the inland deserts. The fauna in the bioregion reflects this diversity, having elements of both monsoon savanna fauna as well as arid zone fauna. A third element is high levels of endemism, occurring neither in the deserts nor the savannas outside the region.

Prior to colonization by Europeans, the Kimberley was managed for hunting and traditional purposes for tens of thousands of years, particularly with the use of traditional burning practices (Vigilante 2001, Vigilante and Bowman 2004). In 1916, the Glenroy Pastoral Company took up pastoral leases over what is now MMDT (which are still under pastoral lease), and the land was managed primarily for cattle production for much of the twentieth century. Mornington and Marion Downs Sanctuaries and Tableland Partnership Area represent Australia's largest privately managed conservation area (with 320,994 ha, 256,811 ha and 308,302 ha respectively, including stock routes). Mornington was acquired by AWC in 2001, and has had an active land management and science program since 2004. Marion Downs was acquired in 2007, and in 2012 AWC entered into partnership with the Yulmbu Aboriginal Corporation to manage Tableland Partnership Area.

MMDT includes 23 ecosystem types, with 11 broad vegetation types, the most dominant being low Eucalypt savanna woodland with mixed grasses (Appendix 1 – Figure A1). A diverse array of plants and vegetation types occur on MMDT, including at least 1,000 plant species, which form a wide variety of plant associations. The great diversity of plants and mosaic of vegetation types is likely due to the climate and complex underlying geology and resulting differences in soil characteristics.

Marion Downs and the northern section of Mornington are dominated by low tree savanna woodland, characterized by Scarlet Gum (*Eucalyptus phoenicea*) and *Eucalyptus ferruginea* over the hard spinifex (*Triodia pungens*). Snappy gum (*Eucalyptus brevifolia*) and spinifex (*Triodia spp.)* is common on rocky areas of central and southern Mornington, while Darwin box (*Eucalyptus tectifica*) and mixed grassland is typical in the deeper volcanic soils of the valleys. Along watercourses, galleries of Paperbark (i.e. *Melaleuca argentea and M. leucadendra*), Leichardt tree (*Nauclea orientalis*), and *Pandanus spiralis* and *P. aquaticus.* represent an important habitat of high diversity.

Mornington and Marion Downs (MMD) Sanctuaries and Tableland Partnership area (MMDT) have a combined 450 confirmed terrestrial and aquatic vertebrate species. Eighteen species are considered threatened either under federal (Environment Protection and Biodiversity Conservation [EPBC] Act 1999) or state (WA Biodiversity Conservation Act 2016) legislation .

Climate and weather summary

The 2019-2020 Kimberley wet season gave below average rainfall, with only 551 mm being recorded from September – June (Figure 2). This was following one of the driest wet seasons on record in 2018-2019 giving only 404 mm. The 2019-2020 wet season was characterised by a late onset, inconsistent and patchy storms until a large monsoonal low in February 2020 and unusually persistent localised storm events into May 2020. The end of 2020 saw a more typical onset to the 2020-2021 wet season, followed by the wettest December 2020 on record for Mornington operations base with large and persistent monsoonal lows (Figure 2). In the 2019-2020 seasons, the average maximum monthly temperatures largely exceeded those of the long-term averages (2004 to 2020) (Figure 2). The exceptions were May and December of 2020, which both received above average rainfalls that likely contributed to the cooler temperatures.

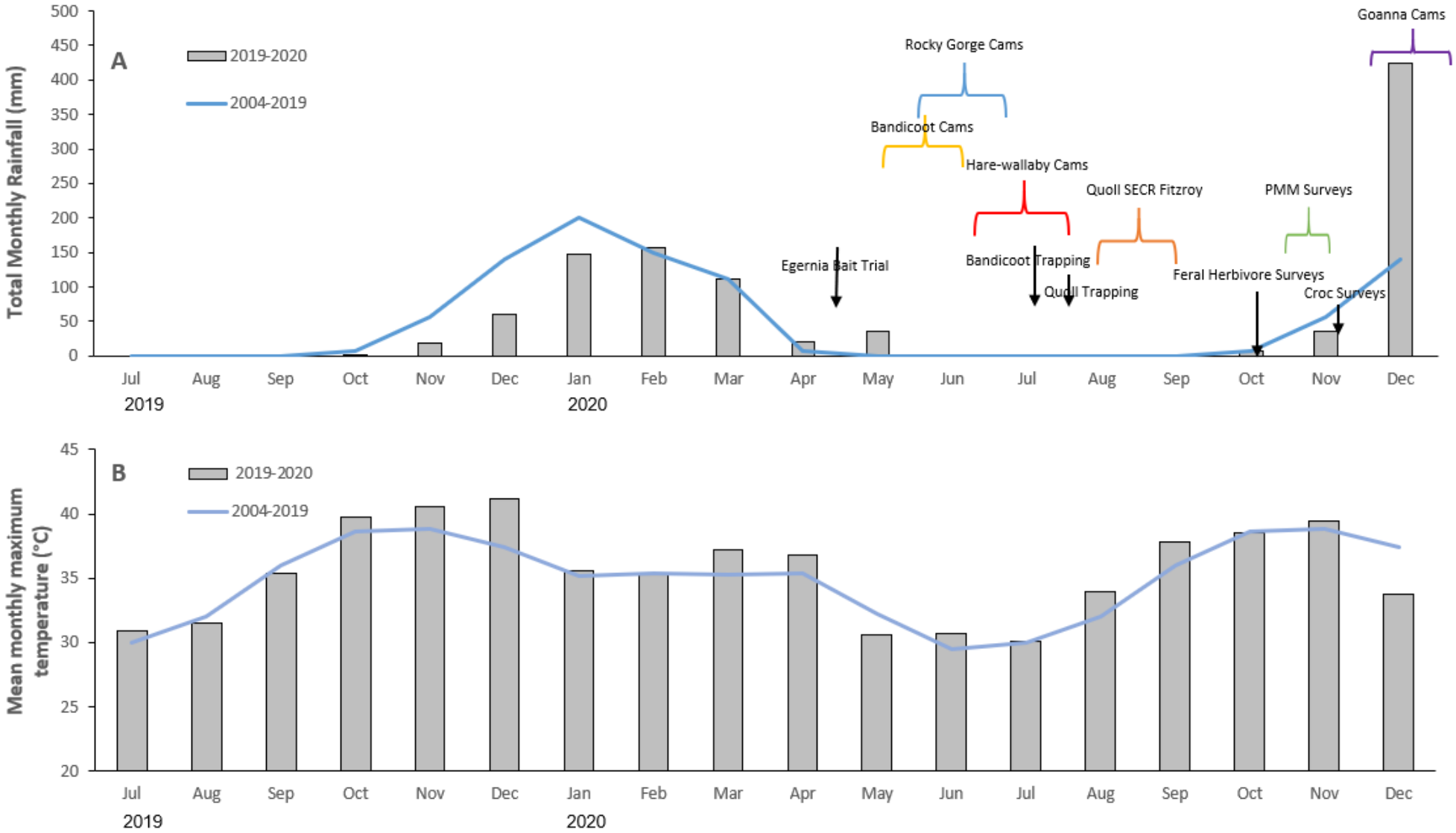

Figure 2. Climate summary for MMDT 2020: A) Total monthly rainfall (mm) and survey timining and B) mean monthly maximum temperature (°C) for MMDT July 2019-December 2020 with historic data for reference (2004-2019). Rainfall data collected from the Mornington operations base. Temperature data are the mean of monthly maximum temperatures from Mt Elizabeth Station (BOM 001018) and Fitzroy Crossing Aerodrome (BOM 003093). Grey bars show July 2019-December 2020 data. Blue lines show median total monthly rainfall for 2004 to 2019 in graph (A) and the mean monthly maximum temperature for 2004 to 2019 in graph (B).

Methods

Indicators and metrics

MMDT's Ecohealth Monitoring Program has been designed to measure and report on the status and trends of species, ecological processes and threats on the sanctuary. The program focuses on selected biodiversity and threat indicators, using metrics derived from data collected through a series of purpose-designed surveys. A selection of species or guilds were chosen as biodiversity indicators which fit into one or more of the following categories: (1) declining and/or threatened species or guilds, (2) strong drivers of ecosystem function, or (3) are a member of the full range of taxa (to enable ongoing surveillance monitoring of a range of taxonomic groups to provide early warning of any unexpected declines).

There are 39 biodiversity indicators (species and guilds) the rationale for their selection is recorded for each indicator in Table 1. In this report, the methods and results are presented for 16 of these indicators for which surveys were carried out in 2020. Threat indicators are selected to monitor the status and trends of changed fire regimes, predators and herbivores and introduced weeds . There are 10 threat indicators (Table 2) of which 5 are reported on in this report based upon 2020 surveys.

Table 1. Biodiversity indicators for Ecohealth monitoring program for MMDT. Rationale for selection: T = threatened or declining; D = driver of ecosystem function; S = surveillance monitoring. Metric definitions: Population estimate = number of individuals; abundance = number of detections per 100 trap-nights or survey; occupancy = proportion of sites recorded (modelled or naive); richness = mean number of species per site; density = detections or individuals per unit distance or area.

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Mammals					
Small-medium mammals					
Echidna (*Tachyglossus aculeatus*)			*	Camera traps (Rocky Gorge Camera Survey)	Abundance, Occupancy
Northern Quoll (*Dasyurus hallucatus*)	*	*	*	Camera traps (Rocky Gorge Camera Survey and Northern Quoll Camera Survey), Northern Quoll Live Trapping (targeted)	Abundance, Occupancy
Ningbing False Antechinus (*Pseudantechinus ningbing*)			*	Camera traps (Rocky Gorge Camera Survey)	Abundance, Occupancy
Long-tailed Planigale (*Planingale ingrami*)			*	Standard Trapping Survey	Abundance, Occupancy
Common Planigale (*Planigale maculata*)			*	Standard Trapping Survey	Abundance, Occupancy
Bandicoots: Northern Brown (*Isoodon macrourus*) and Golden Bandicoots (*Isoodon auratus*)	*	*	*	Camera traps (Bandicoots Targeted Survey), Standard Trapping Survey	Abundance, Occupancy
Spectacled Hare Wallaby (*Lagorchestes conspicillatus*)	*		*	Camera traps (Spectacled Hare-wallaby Targetd Survey)	Occupancy
Short-eared Rock-wallaby (*Petrogale brachyotis*)			*	Camera traps (Rocky Gorge Camera Survey)	Abundance, Occupancy
Central Pebble-mouse (*Pseudomys johnsoni*)			*	Central Pebble-mouse Targeted Survey	Mound density
Western Chestnut Mouse (*Pseudomys nanus*)			*	Standard Trapping Survey	Abundance, Occupancy
Common Rock Rat (*Zyzomys argurus*)			*	Camera traps (Rocky Gorge Camera Survey)	Abundance, Occupancy
Pale Field Rat (*Rattus tunneyi*)			*	Standard Trapping Survey	Abundance, Occupancy
Rocky gorge small-medium sized mammal guild (dasyurids, rodents)			*	Camera traps (Rocky Gorge Camera Survey)	Abundance, Richness

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Small-medium sized mammal guild (dasyurids, rodents)			*	Standard Trapping Survey	Abundance, Richness
Large herbivores					
Large macropods			*	Methods in development	Abundance, Richness
Predators					
Dingo (*Canis lupis dingo*)		*		Camera traps (predator)	Occupancy, Abundance
Bats					
Microbats – guild			*	Methods in development (acoustic surveys)	Abundance, Richness
Reptiles					
Small-medium reptiles					
Small reptiles – skinks and dragons			*	Standard Trapping Survey	Abundance, Richness
Small reptiles – geckoes and flap-footed lizards			*	Standard Trapping Survey, Geckoes – targeted spotlight	Abundance, Richness
Other reptiles					
Blue-tonge Skink (*Tiliqua scincoides*)	*	*	*	Camera traps (Large Reptile Camera Survey)	Occupancy, Abundance
Yellow Spotted Monitor (*Varanus panoptes*)	*	*	*	Camera traps (Large Reptile Camera Survey)	Occupancy, Abundance
Rock monitor guild Black-palmed Rock Monitor (*Varanus glebopalma*) Kimberley Rock Monitor (*Varanus glauerti*) Ridge-tailed Monitor (*Varanus acanthurus*)		*	*	Camera traps (Large Reptile Camera Survey, Rocky Gorge Camera Survey)	Occupancy, Abundance
Water monitor guild Mitchell's Water Monitor (*Varanus mitchelli*) Merten's Water Monitor (*Varanus mertensi*)	*		*	Camera traps (Large Reptile Camera Survey, Rocky Gorge Camera Survey)	Occupancy, Abundance
Freshwater Crocodiles (*Crocodylus johnsoni*)			*	Aerial surveys, Freshwater Crocodiles Spotlighting Survey	Density
Birds					
Seed-eating (Granivorous) birds					
Gouldian Finch (*Erythrura gouldiae*)	*			Waterhole Survey	Abundance, Occupancy
Seed-eating (Granivorous) birds – guild	*		*	Waterhole Survey	Abundance, Richness
Savanna birds					
Savanna woodland birds – guild	*		*	Diurnal Bird Surveys	Abundance, Richness
Riparian birds					
Purple-crowned Fairywren (*Malurus coronatus*)	*		*	Purple-crowned Fairywren Targeted Survey	Population estimate, Density
Nocturnal birds					
Nocturnal birds – guild			*	Nocturnal Bird Spotlighting Survey	Density
Frogs					
Frogs – guild			*	Methods in development	Abundance, Richness
Vegetation					
Tree cover and composition		*	*	Habitat Structure Surveys	TBC

Indicator	Rationale			Survey method	Metric/s
	T	D	S		
Shrub cover and composition		*	*	Habitat Structure Surveys	TBC
Ground cover and composition		*		100 steps	Extent, Density
Ground cover				Habitat Structure Surveys	Extent
Hollow logs		*		Habitat Structure Surveys	TBC
Woody Debris		*		Habitat Structure Surveys	TBC
Obstructions to water flow		*		Landscape Function Analyses	TBC
Callitris Pine	*	*	*	Methods TBC	TBC
Mountain White Gum (*Eucalyptus mooreana*)	*	*	*	Methods TBC	TBC

Table 2. Threat indicators for Ecohealth monitoring framework for MMDT. Metric definitions: Population estimate = number of individuals, density = detections or individuals per unit area or distance; activity = number of records per survey; abundance = detections/ 100 trap nights; occupancy = proportion of sites recorded; extent of infestation = area known to occur.

Indicator	Rationale	Survey method	Metric/s
Feral predators			
Feral cat (*Felis cattus*)	Major threat to wildlife	Camera traps (predator)	Abundance, occupancy
Feral herbivores			
Cattle (*Bos taurus*)	Threat to wildlife, vegetation	Aerial Survey	Population estimate
Horse (*Equus caballus*)	Threat to wildlife, vegetation	Aerial Survey	Density
Donkey (*Equus asinus*)	Threat to wildlife, vegetation	Aerial Survey	Density
Pig (*Sus scrofa*)	Threat to wildlife, vegetation	Methods under development	Occupancy, abundance
Other threats			
Cane toad (*Rhinella marina*)	Threat to wildlife	Camera traps (Rocky Gorge Camera Survey and Large Reptile Camera Survey), Standard Trapping Survey	Occupancy
Weeds			
Grader Grass (*Themeda quadrivalvis*)	Weed of National Significance	Vegetation surveys, targeted surveys under development	Extent of infestation (categorised by distribution)
Parkinsonia (*Parkinsonia aculeata*)	Weed of National Significance	Vegetation surveys, targeted surveys under development	Extent of infestation (categorised by distribution)
Other weeds (Rubber Bush, Butterfly Pea and Stylo)	Threat to vegetation, changes to fire regime	Vegetation surveys, targeted surveys under development	Plants treated, Person Hours
Fire			
Suite of ecologically relevant metrics, calculated for (i) all fire; and (ii) wildfire	Key driver of vegetation dynamics, structure and composition, habitat attributes	Remote sensing, ground traverse	Extent, Frequency (no. times burnt in given period), Time since fire, Distance to unburnt (mean, maximum)

Survey effort

In 2020, Ecohealth surveys for MMDT consisted of a series of camera arrays, aerial surveys, spotlighting surveys and a series of targeted surveys. These surveys attempt to cover the major habitat types and vertebrate groups on MMDT, while also providing geographic representation and replication. Further details on the survey design (number of sites, locations and stratification) and methods for individual surveys conducted in 2020 are below. Methodology may change slightly year to year through refinement and suggestions from the Department of Biodiversity, Conservation and Attractions (DBCA) ethics committee. For a full list of survey effort, total number of trap-nights, distance of surveys flown or walked refer to the Survey Effort Section of this report (Table 3).

Due to restrictions on travel around COVID-19, some Ecohealth surveys were not able to be undertaken on MMDT in 2020 because of their heavy reliance on volunteer involvement. The omitted surveys were: Standard Trapping Survey, vegetation structure, diurnal bird surveys and granivorous bird waterhole surveys. Additionally, predator camera arrays and aerial surveys for Freshwater Crocodile, *Callitris intratropica* and *Eucalyptus mooreana* were not completed.

Table 3. Survey effort for all listed indicators for Ecohealth monitoring program surveys on MMDT in 2020. Live-trapping and camera effort is measured in trap-nights (TN), surveys are total counts of surveys and transects are measured in distance (km). For targeted surveys see relevant sections in Survey Methods for finer detail.

Survey	Effort	Description/Comment
Camera Surveys	**3,425 (TN)**	
Rocky Gorge Camera Survey	2,900 (TN)	5 camera array at 20 sites (*n* = 100) spaced 150-200 m apart for 29 nights each.
Large Reptile Camera Survey	525 (TN)	15, 8 or 7 x camera array at 7 sites (*n* = 75) for 7 nights in sandy riparian, escarpment and rocky gorge habitats. *Survey not completed at Lady Forest escarpment in 2020*
Targeted camera surveys	**7,704 (TN)**	
Northern Quolls Camera Survey	1,740 (TN)	10 cameras each at North and South Sir Jonn Gorge for 12 nights. 15 SECR cameras at 7 sites along Sir John Gorge for ~14 nights.
Bandicoots	2,520 (TN)	5 cameras at 18 sites for 28 nights each spaced 50 m apart.
Central Pebble-mouse	644 (TN)	1 camera at 24 sites for ~28 nights.
Spectacled Hare-wallaby	2,800 (TN)	10 cameras at 10 sites spaced 100 m apart for 28 nights.
Live trapping	**385 (TN)**	
Northern Quoll Live Trapping *Bandicoot Targeted Survey* *Central Pebble-mouse Targeted Survey*	160 (TN) 96 (TN) 129 (TN)	10 Elliot & 10 cage traps on each side of Sir John Gorge for 4 nights. 20 Elliot & 12 cage traps (split between 2 sites) for 3 nights. Elliot traps set for 3 nights at Top Bore and 2 nights at Cleanskin.
Spotlight Surveys	**66 km**	
Nocturnal Birds	60 km	Nocturnal birds spotlighting along roads – trial survey.
Freshwater Crocodile	6 km	Spotlighting on waterways.
Aerial Surveys	**886 km**	
Feral Herbivore	886 km	Aerial survey over both stocked and destocked areas.
Other		
Purple-crowned Fairywren Targeted	2 surveys	Twice annual census by Monash University.

Survey design and methods

Rocky Gorge Camera Survey

Small-medium sized mammals and cane toads were surveyed using the Rocky Gorge Camera Survey at 20 rocky gorge sites across MMDT in May 2020 (Figure 3). Five cameras were deployed at each site (total of 100) for 29 nights, totalling 2,900 trap-nights (145 per site). At each site, cameras were deployed in a linear transect along the gorge approximately 50-60 m apart. Cameras were set between 0.5-1 m above the ground and angled between 45-90° downward towards a bait of peanut butter, oats and mackerel (NWET 2019).

Remote camera arrays, even when they have a narrow-stated target such as Northern Quolls, bandicoots or varanids, are intended as broad-spectrum surveys. A large camera array will typically detect enough off-target species, especially rare species, to be useful for monitoring a variety of indicators. With this in mind, the various camera arrays described here, and in the method sections below, are designed to survey the major habitats and taxa that are not well surveyed by the Standard Trapping Survey (e.g. rocky habitats, creek beds, roads, waterholes, and refugial pockets). Furthermore, all cameras were set on 'High' sensitivity and 'Rapidfire' taking 5 photos per trigger with no quite period between triggers.

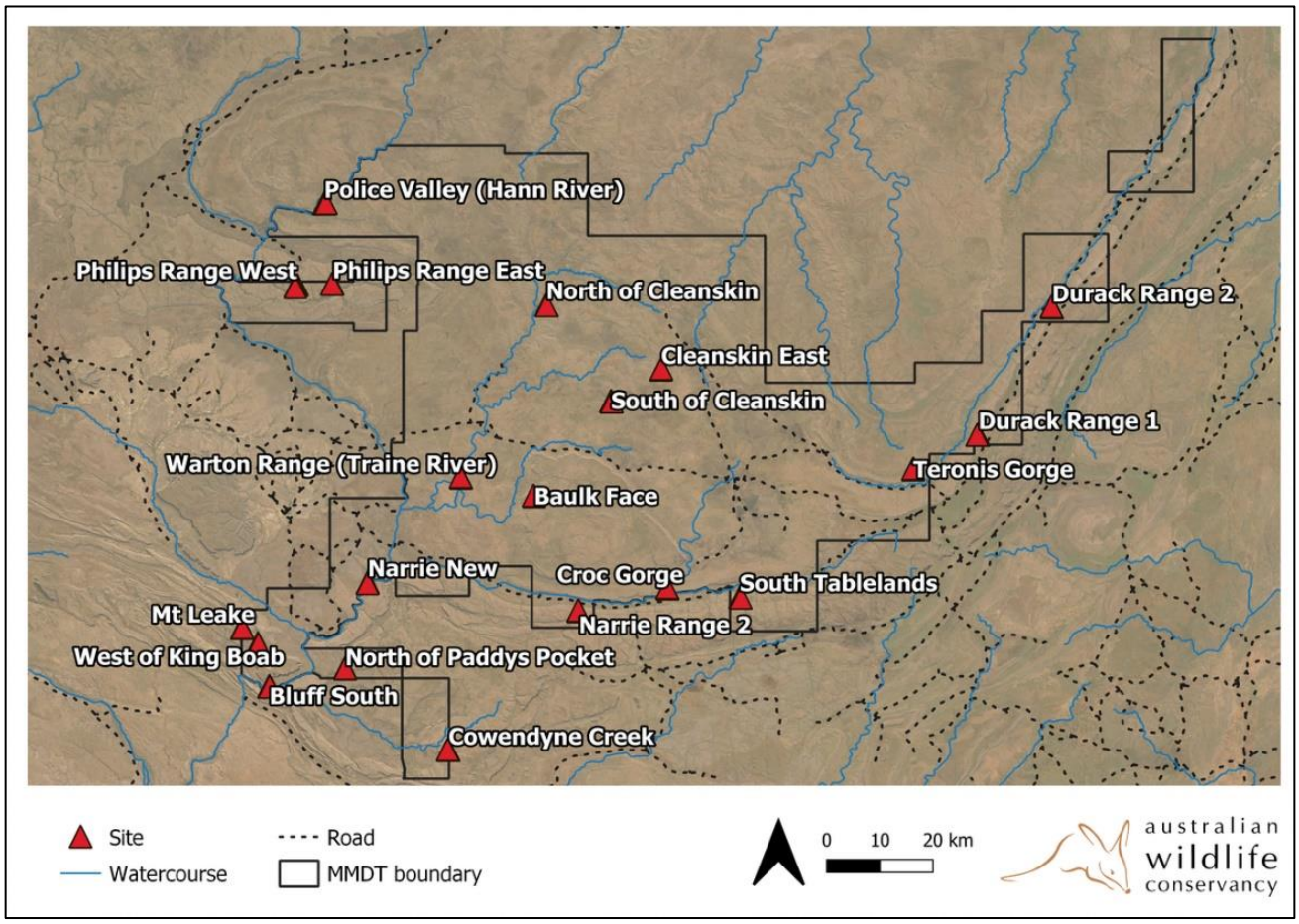

Figure 3. Map of the 20 Rocky Gorge Camera Survey sites surveyed in May 2020 on MMDT. Each site had 5 x cameras – totalling 100 cameras across 20 sites, deployed for a total of 29 nights each.

Northern Quoll Camera Survey

Two camera trap arrays (10 cameras per array) were deployed along 1 km on the north and south sides of the Fitzroy River at Sir John Gorge for 12 nights in June 2020, totalling 240 trap nights (Figure 4). Cameras were baited with peanut butter, oats and mackerel, and set at approximately 0.5 m off the ground, facing vertically down to facilitate individual quoll identification based on dorsal spot patterns.

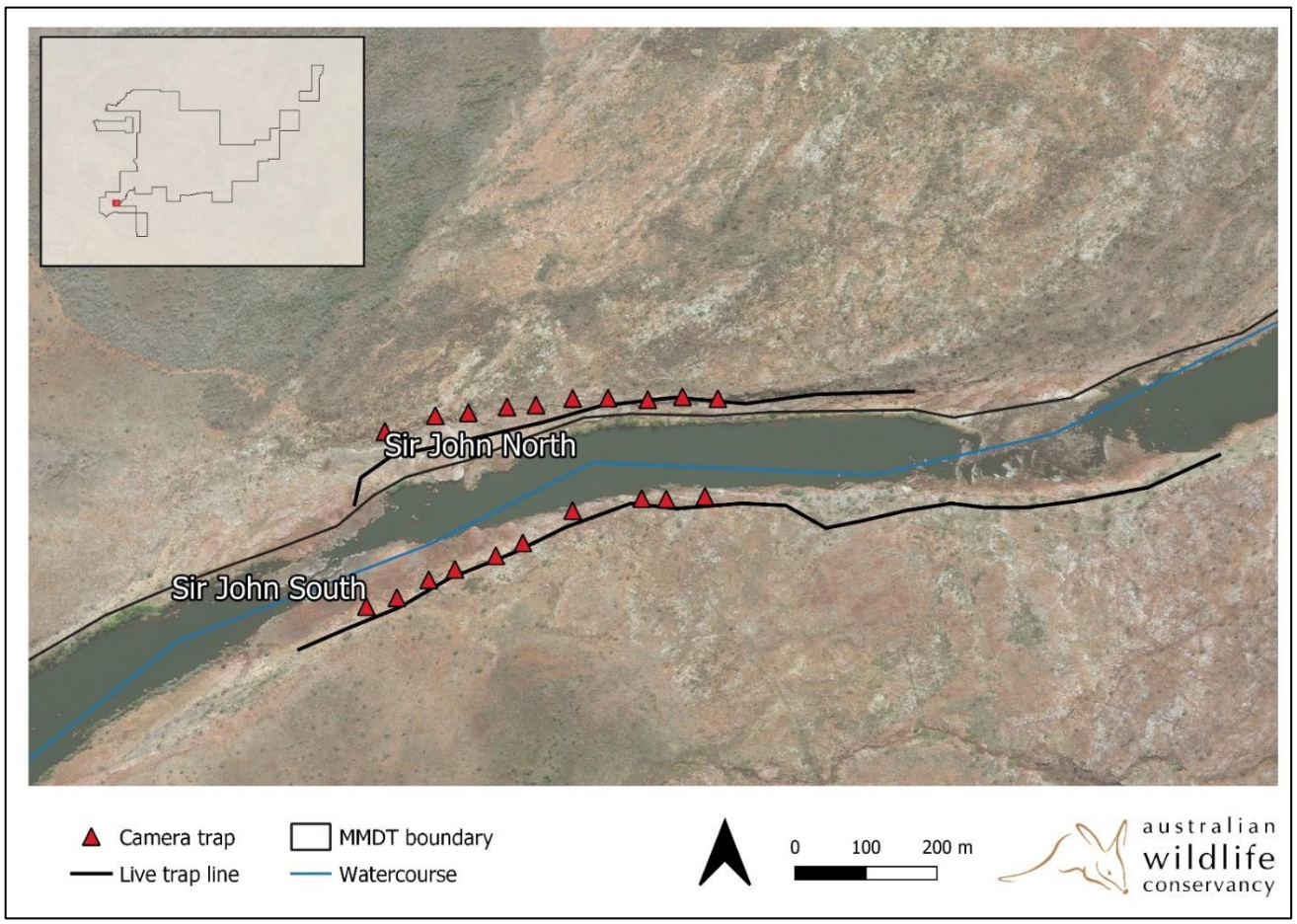

Figure 4. Location of camera traps (red triangle; Northern Quoll Camera Survey) and cage trap line (black; Northern Quoll Live Trapping Survey) at Sir John Gorge for targeted Northern Quoll surveys in June 2020.

Northern Quoll Live Trapping Survey

The Northern Quoll Live Trapping Survey is an annual targeted live trapping for Northern Quolls conducted at Sir John Gorge in mid-July 2020 over four nights for a total of 160 live trap nights (historical live trapping effort in Appendix 2 – Northern Quoll Live Trapping Survey). A total of 10 cage traps and 10 Elliot traps were deployed alternating in a transect on each side of the gorge (Sir John north n = 20 and Sir John south n = 20, Figure 4), with traps spaced approximately 40 m apart. Traps were set and baited with a ball of peanut butter, oats and mackerel in the late afternoon and checked early each morning. Non-target captures were released. Northern Quolls captured were sexed, aged, PIT tagged and measurements of weight and PES taken prior to release. For genetic analysis, a tissue sample from the tip of the ear was taken using sterilised forceps and scissors (dipped in 100% ethanol and heated under a flame) and placed in a vial containing 70% ethanol solution.

Bandicoots Targeted Survey: Northern Brown Bandicoot and Golden Bandicoot

Bandicoot Camera Survey

Bandicoot occurance on southern Mornington was surveyed in May 2020 by deploying camera traps at 18 sites (totalling 2,520 trap nights) within sandseep and riparian habitats (Figure 5). Sites were located in clusters of three with each locality being at least 1 km apart, and within each site five cameras were deployed, each 50 m apart.

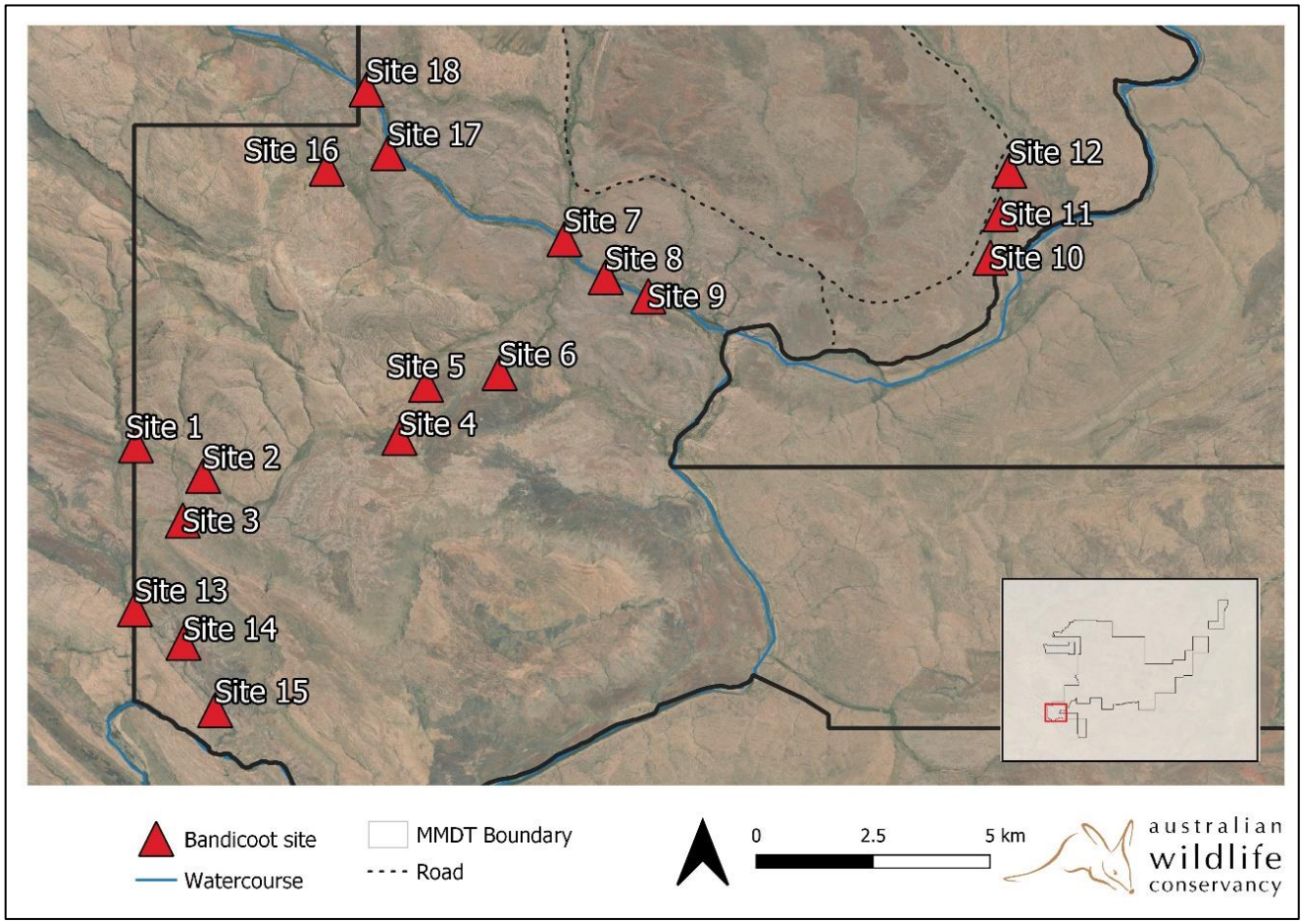

Figure 5. Location of 18 Bandicoot Camera Survey sites, distributed across the southern Mornington landscape in riparian and sandseep habitats. Site 1 is the location of all bandicoot records in 2020.

Bandicoot Live Trapping Survey

After the Bandicoot Camera Survey at southern Mornington sites, follow up live trapping was conducted in July at sites with Bandicoot camera detections to obtain genetic samples for identification (Riles B 2020).

A separate live-trapping survey was also undertaken at Phillips Range, Marion Downs, following a fire which burnt out a rainforest pocket in July 2020 (Figure 6). This survey is part of a longer term data set for Phillips Range and is usually collected during Standard Live Trapping, which was not undertaken this year. Thus additional surveys were undertaken to maintain the yearly Bandicoot dataset. A total of 12 cage and 20 Elliott traps were deployed equally between the two sites along a riparian strip and within a rainforest pocket. Traps were set approximately 50 m apart within each site and remained open for three nights each (totalling 96 trap nights).

For every bandicoot caught, the sex, age, weight and breeding status were recorded, and individuals were marked on the ear with a non-toxic marker. To examine potential morphometric differences between the two bandicoot species, measurements of pes, testis, teats, tail, head, body and ears were taken for all captured bandicoots. For genetic analysis, a tissue sample from the tip of the ear was taken using sterilised forceps and scissors (dipped in 100% ethanol and heated under a flame) and placed in a vial containing 70% ethanol solution.

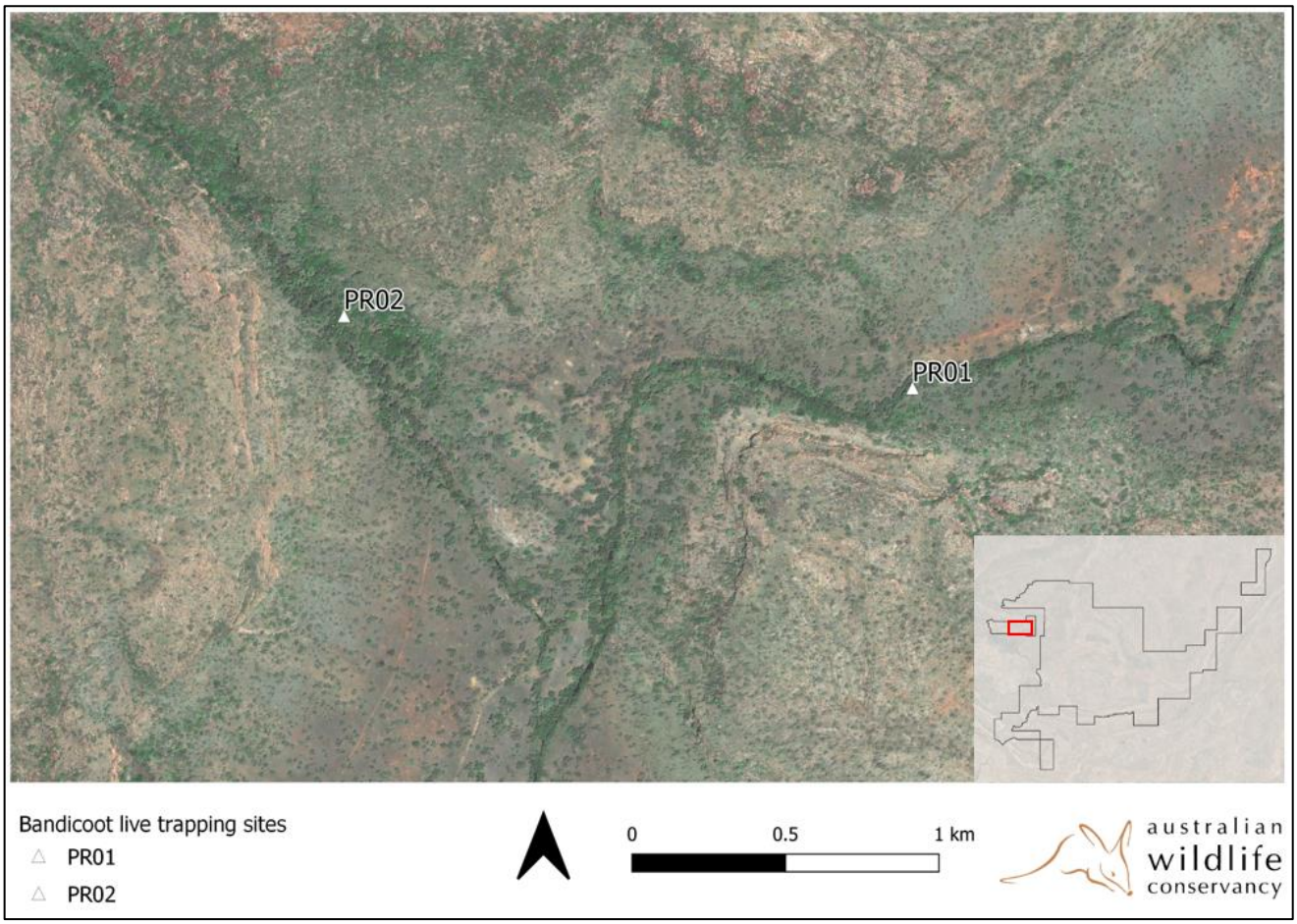

Figure 6. Location of 2 Bandicoot Live trapping sites at Phillips Range, Marion Downs, in 2020.

Central Pebble-mouse Targeted Survey

In 2020, inventory Central Pebble-mouse (CPM) surveys were undertaken at two locations: Top Bore and Cleanskin (Figure 7) using three key methodologies: camera- and live-trapping aimed to confirm the presence of CPM on mounds, and active searches and mound assessments were used to expand the known extent and record the condition of known pebble-mounds on Mornington (Stockwell 2020a, 2020b). For the 2020 Ecohealth monitoring program the metric reported is derived from data collected during pebble-mound searches, as such, only this method is outlined below.

Pebble-mound active searches

During active searches, 15.1 km was covered at Top Bore and 42.5 km was covered in three areas of Cleanskin where mounds were known to occur. All known mounds were visited, and new mounds encountered were marked.

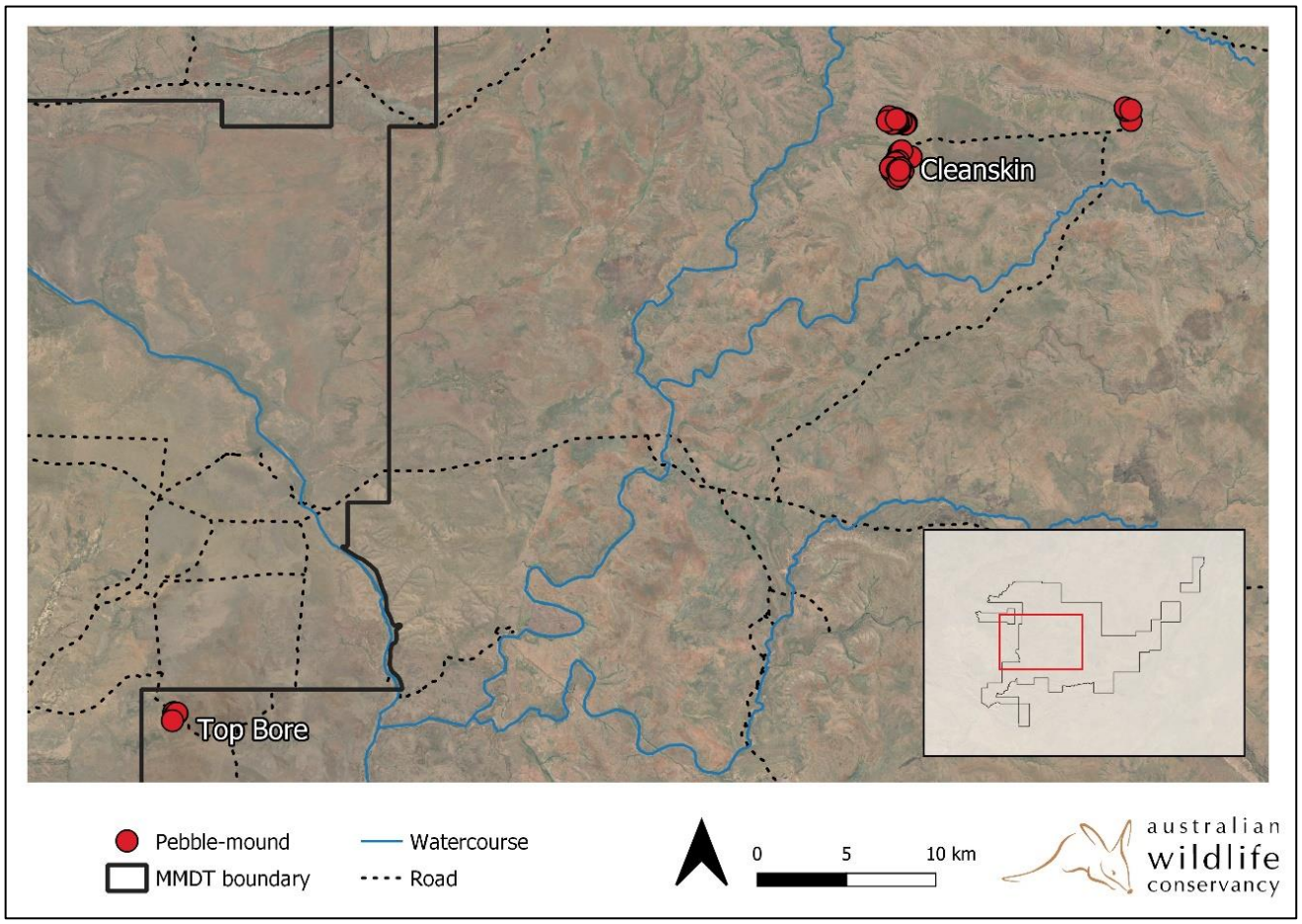

Figure 7. Location of Central Pebble-mouse Targeted Surveys (active searches, live trapping and cameras) at Top Bore and Cleanskin on MMDT in October/ November 2020.

Spectacled Hare-wallaby Targeted Survey

Spectacled Hare-wallabies (SHW) were surveyed using camera traps at 10 sites on Mornington and Tableland Sanctuaries following a desktop analysis of factors listed below and preliminary site inspections (vehicle based) to ground truth potential sites (Figure 8).

- Locations of previous detections of SHW from 2014, 2018 and 2019.
- Coverage in suitable habitat across Mornington and Tableland Sanctuaries.
- Proximity to 2020 burn scars and suitable soil type, vegetation structure and floristics.
- The ecology of SHW such as diet and foraging, refugia/shelter sites and home range.
- Road access, camera availability (100) and logistics.

Sites were a minimum of 2 km apart and consisted of 10 cameras spaced 100 m apart. This spacing aimed to provide suitable spatial coverage, given the home range of SHW is estimated to be between 10-180 hectares (McCosker 1997; Woinarski et al. 2014).

Cameras were positioned in a linear layout within the interface of recent burn scars and unburnt refugia/shelter (Porter 2020). Seven of the 10 cameras at a site were located in the burn scar within 30 m of nearby unburnt shelter. The remaining three cameras were located in the unburnt portion of the habitat where there was greater shelter for each of the 10 arrays. Cameras were baited with peanut butter and oats in a contained bait canister or smeared on a rock or suitable log. Each site had two bait canisters in the burnt area with the remaining cameras containing a smear on a rock. Cameras were mounted on trees 1.5-2 m from the bait on a 45° angle. The area surrounding the bait was cleared of vegetation to prevent false triggers. Cameras were deployed in mid-late June, when there was fresh green pick from regenerating plants following early dry season eco-fire burns. All cameras were deployed for 28 days, totalling 2,800 trap nights of survey effort.

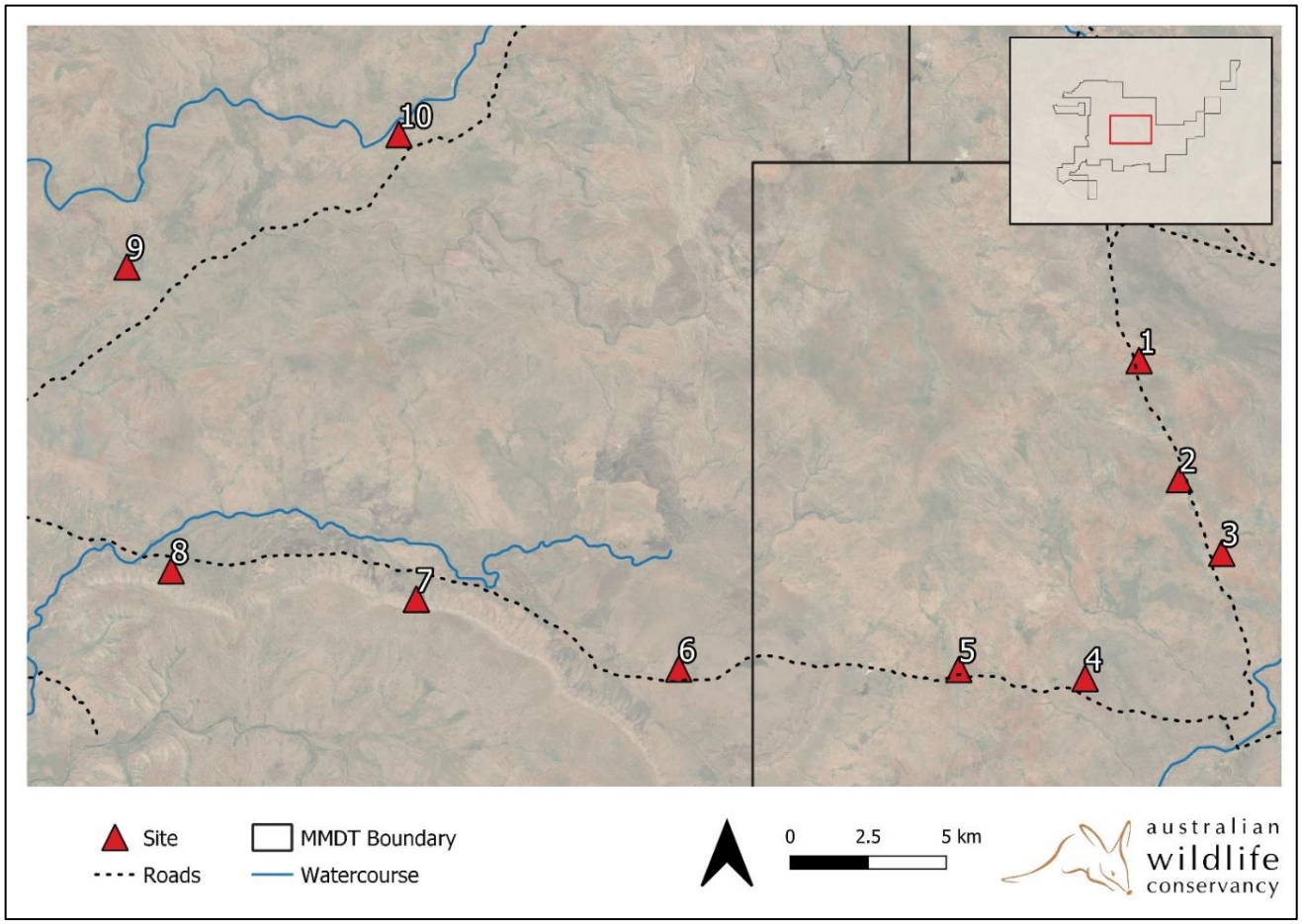

Figure 8. Camera trapping site locations (n = 10) for Spectacled Hare-wallaby Targeted Surveys on Mornington (western sites) and Tableland (eastern sites) Sanctuaries.

Large Reptile Camera Surveys

Surveys for large reptiles commenced in November 2016 at 8 sites on southern Mornington. Annual surveys continued at a subset of sites in November-December 2017-2020, to assess the persistence of susceptible reptile species following the arrival of the cane toad in 2017.

Camera arrays to monitor large reptile species (goannas and blue-tongue skink species) were deployed in December 2020 following suitable rainfall conditions, when all target species were presumed active. In 2020, one seasonally dry escarpment site, Lady Forest Range (*n* = 15), was not completed due to an early wet season cutting off access across the Adcock River. Cameras (*n* = 75; Figure 9) were deployed at 7 sites, for 14 days. Each camera was set at a distance approximately 1.5 – 2 m from bait, and fixed no higher than 2 m at a 45 degree angle to target. Each camera was baited with a mixutre of sardines, beef mince and egg. Camera arrays were deployed in target habitat types including:

- sandy riparian (Bluebush [*n* = 15] and Cadjeput [*n* = 15]);
- rocky gorge (Mt Leake Gorge [*n* = 8], Spider Gorge [*n* = 8], King Boab Gorge [*n* = 7], Bluff Pools [*n* = 7]), and;
- seasonally dry escarpment (Home Range [*n* = 15]; (Figure 9).

Individual reptiles were identified for each site using unique dorsal and lateral markings.

It is anticipated that from 2020 onwards the Large Reptile Camera Survey targeting large, toad-susceptible, reptiles on Mornington will be completed every two years, to monitor the long-term impact of cane toads on persistence and abundance.

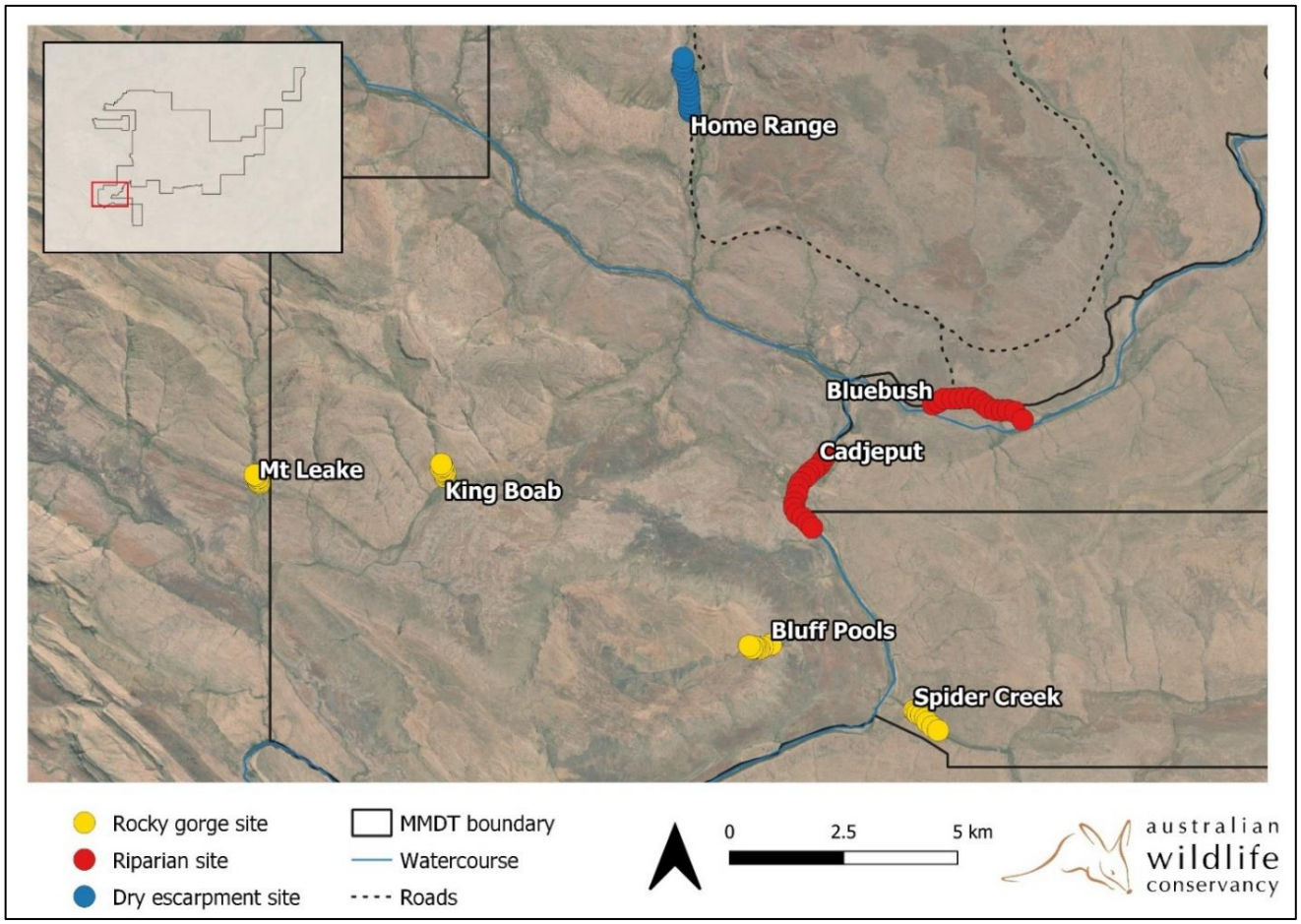

Figure 9. Location of the 7 Large Reptile Camera Survey arrays (total cameras n = 75) in seasonally dry escarpment (Home Range [n = 15], blue circles), sandy riparian (Bluebush [n = 15 and Cadjeput [n = 15], red circles) and rocky gorge (Bluff Pools [n = 7], King Boab [n = 7], Mt Leak Gorge [n = 8] and Spider Creek [n = 8], represented by yellow circles) habitat type on southern Mornington.

Freshwater Crocodiles Spotlighting Survey

A kayak-based spotlight monitoring program for Freshwater Crocodiles was established in 2016 to assess baseline pre-toad population densities in two habitat types (sandy riparian and rocky gorge) along the Fitzroy River. In 2020, 5.91 km of Kayak-based spotlight surveys were completed at five sites: Bluebush, Cadjeput, Staff Bluebush, Dimond Gorge and Sir John Gorge (Figure 10). Spotlight surveys were completed by a single observer, using a standardised LED head torch (Led Lenser H14R.2 – 1000 lumens) with 'Boost' function. The size of individual crocodiles was estimated and GPS co-ordinates marked. Surveys were completed at the end of the dry season, before the first significant rains (November), when permanent pools were still isolated and clearly separated from nearby habitat.

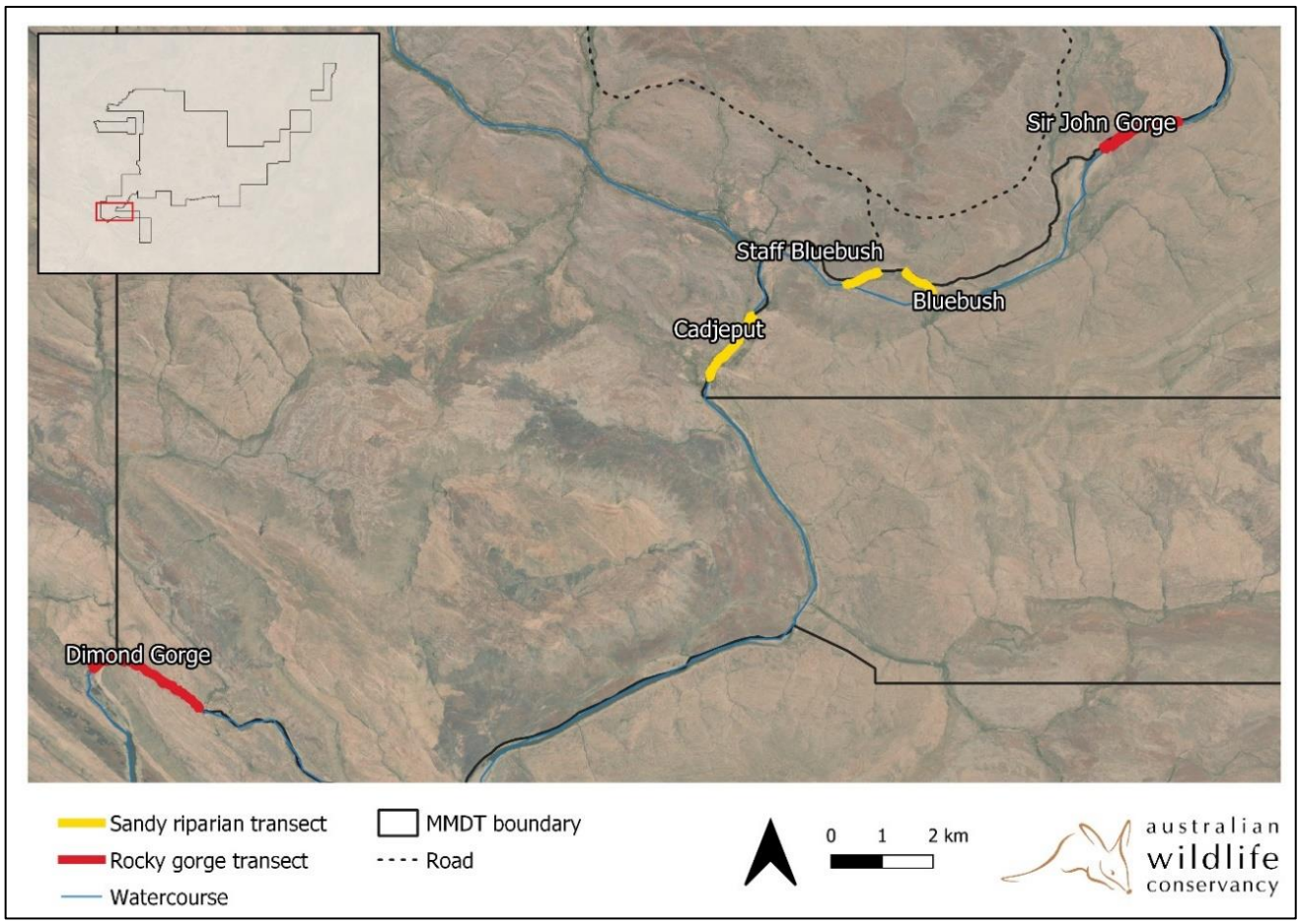

Figure 10. Location of Freshwater Crocodile spotlight transects by kayak (5.91 km) at five sites on the Fitzroy River, Mornington in November 2020. The most south-western and north-eastern transects are in rocky gorge habitat (red lines; Dimond Gorge and Sir John Gorge respectively) while the central transects are in sandy riparian habitat (yellow lines; Cadjeput, Staff Bluebush and Bluebush).

Nocturnal Birds Spotlighting Survey

In June 2020, two trial road-based spotlight surveys for nocturnal birds (targeting Nightjars, Tawny Frogmouth, Southern Boobook, Barking Owl, Eastern Barn Owl, Bush Stone-curlew) were conducted on a 30 km stretch of the Marion Downs Road (Figure 11). This habitat was primarily savanna dominated with some nearby rocky hills. Two observers (including driver) spotlighted and recorded all sightings straight ahead to 90° either side of the vehicle. The start and finish times and locations were recorded for each trial, as well as, all nocturnal bird detections. A constant speed between 20-30 km/hr was maintained throughout each trial.

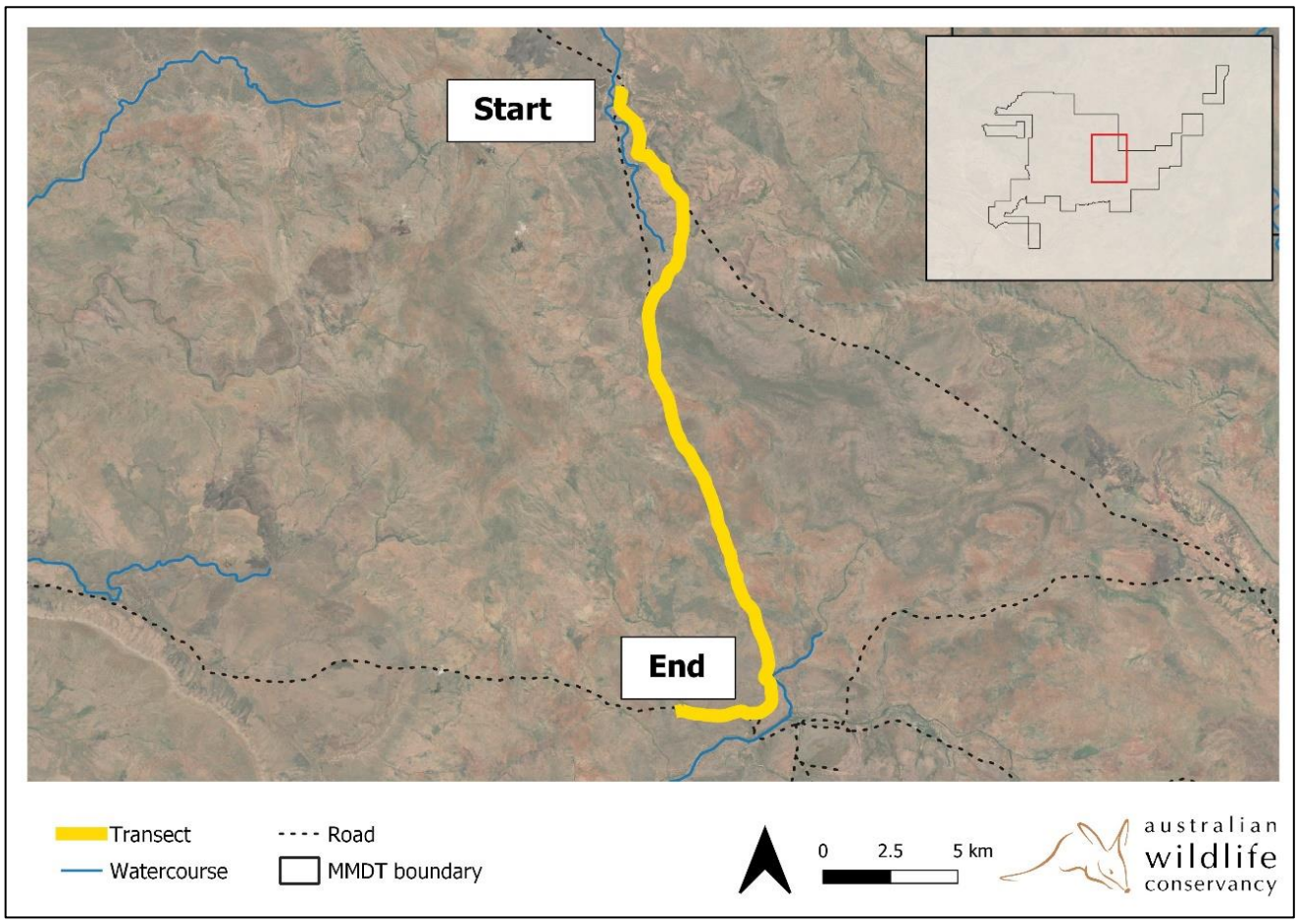

Figure 11. Road transect (30 km) driven during Nocturnal bird spotlight survey trials on Marion Downs in June 2020.

Purple-crowned Fairywren Targeted Survey

The Purple-crowned Fairywren project is led by Associate Professor Anne Peters of Monash University in collaboration with AWC and in 2020, the fieldwork was completed by Dr. Niki Teunissen.

Population status (focus area – Annie Creek & Adcock River): All individuals within the focus area, a 15 km-stretch of Annie Creek and the Adcock River on Mornington, are (re)sighted, and their territories identified during a census. This census, replicated since 2005, generates a twice annual population estimate.

Feral Herbivores Aerial Surveys

In November 2020, large feral herbivores were surveyed via aerial surveys and a total of 886 km was flown 100 m above ground level at approximately 100 km/hr, covering approximately 17,700 ha (representing approximately 2% of MMDT; Figure 12). Four crew members (including one pilot) observed and recorded all cattle, horses and donkeys seen, and whether they are inside or outside a 45° angle from straight down (this gives an 'inside' transect width of 200 m). Although it is possible to miss cattle within this 200 m transect, it is unlikely enough that it is considered to be a near-census. Cattle numbers beyond this 200 m transect (i.e. from 45° out to the horizon) are recorded for comparison with historic data.

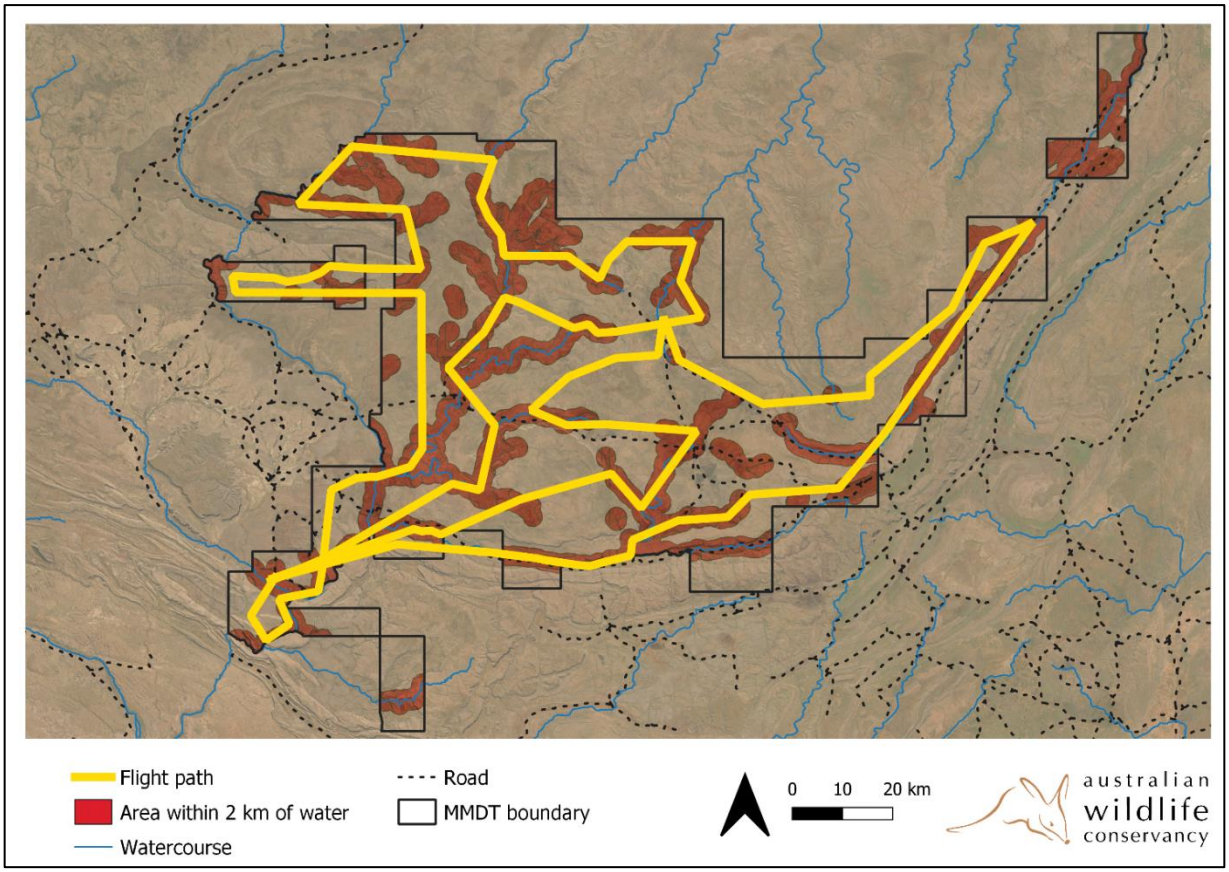

Figure 12. The 2020 Feral Herbivore Aerial Survey flight path and area within a 2 km distance of permanent water sources on MMDT.

Analysis methods

The following methods were used to calculate metrics for MMDT 2020 EcoHealth indicators:

Population estimate:
The population estimate for the Purple-crowned Fairywren is based on the total number of individuals sighted, which are all individually banded and identifiable.

Feral cattle population estimates were arrived at using a two step approach. Firstly, cattle densities were calculated from Feral Herbivores Aerial Survey observations and survey area. These densities were calculated separately for each sanctuary and for each of 5 pastoral productivity classes (unsuitable, very low, low, moderate, and high). Densities were then extrapolated onto areas within a 2 km buffer of permanent water sources (Figure 12), with appropriate densities used for each pastoral productivity class. Extrapolated values for each pastoral productivity class were summed to estimate the cattle population within a 2km buffer of water. Using extensive GPS tracking of cattle, AWC research has found that cattle spent ~97% of time within 2km of water during late dry season (Rangelands NRM et al. 2016). For population size calculations, the area surveyed within two kilometres of water was 10,565 ha overall (or 4,180 ha, 3296 ha and 3,086 ha for Mornington, Marion Downs and Tableland respectively).

Abundance: the number of detections (live traps = number of individuals (excluding recaptures), camera traps = independent 'visits') per 100 trap-nights. A 'visit' is defined as a new detection of a species, or rededection of the same species, in greater than 5 min interval. An exception to this is the abundance metric for large reptiles detected on camera traps = number of individuals per 100 trap nights, as these species have unique dorsal markings allowing identification of individuals from camera data.

Here, trap-nights are only included where a trap type targets the indicator appropriately. For example, funnel trap-nights are excluded for small mammals, and cage and Elliot traps are excluded for small reptiles.

Richness: the average number of species detected per sampling site (trap, camera, or survey site).

Density: is calculated as the number of detections per unit distance or area surveyed:

- Central Pebble-mouse: mounds per km searched
- Purple-crowned Fairywren: number of individuals per km
- Freshwater Crocodile: individuals sighted per kilometre of waterway surveyed
- Feral Herbivore densities were calculated from Feral Herbivore Aerial Survey observations as number of individuals per km

Occupancy: the proportion of sites where a species was detected

Fire Scar Analysis
Fire scar data were obtained for 2000 to 2020 from the North Australia Fire Information (NAFI) website. Each scar was attributed by year, month and season. In most years, fire scars detected from January to June (inclusive) were attributed as 'Early', whereas those detected July to December were attributed as 'Late'. In 2020 unusually high rainfall in April and May resulted in cool burning conditions lasting longer and July was included in the 'Early' season. The maps and statistics for the analyses were created using ArcGIS with Spatial Analyst, and were semi-automated using Python scripting. Graphs were produced using Microsoft Excel. Cooper et al. (2020) provide further detail on the annual fire scar mapping and analysis undertaken.

Results

Biodiversity metrics

Mammals

Small-medium mammals

Rocky gorge small-medium sized mammals

In 2020, 1,496 mammal visits were recorded throughout the 2,900 trap nights across all 20 rocky gorge sites (Table 4; Figure 3). Of these visits, 5 small-medium sized mammal species were positively identified: Common Rock Rat, Ningbing False Antechinus, Short-beaked Echidna, Rock Ringtail Possum and Short-eared Rock Wallaby. No Rakali or Northern Quolls were detected on the Rocky Gorge Camera Survey in 2020 (Table 4).

Rocky gorges and escarpments occur over a large area of the Kimberley, including on MMDT. These areas form important habitat for many species due to their topographical complexity, which provides protection from feral cats (Hohnen et al. 2016). There is also a tendency for a more patchy and less intense burning regime compared with other landscapes in the Kimberley (Bradley et al. 1987). Rocky habitats therefore function as important refugia for many species, some of which are rocky habitat specialists or otherwise more abundant in these habitats (Hohnen et al. 2016).

Table 4. Small mammal occupancy, visits and abundance from 2020 camera survey of 20 Rocky Gorge Camera Survey sites on MMDT (2,900 trap-nights). Visit = discreet capture event separated from another of the same species by at least 5 min. Occupancy = proportion of sites with a detection. Abundance = visits per 100 trap-nights. The 'small mammal guild' includes only dasyurids and rodents whose range includes MMDT.

Species	Occupancy (%)	Total visits	Abundance	Comments
Echidna	15	6	0.20	One more visit in 2020 than in 2018 (n = 5). Echidna were in similarly low abundance in 2020 but had a higher occupancy, occurring at 3 sites in 2020 rather than 2 in 2018.
Northern Quoll	0	0	0.00	There were no detections of Northern Quolls in the 2020 rocky gorge array. In 2018, 2 individual quolls were identified from 3 visits across 2 sites (Narrie Range 1 and Cowendyne Creek – see (Figure 3), based on their unique spot pattern. In 2018, the occupancy was 16% and abundance 0.11.
Ningbing False Antechinus	25	19	0.70	Detected at 5 sites in 2020 (compared to 8 in 2018), spread widely across MMDT.
Common Rock Rat	100	774	26.70	Most prevalent small mammal detected, accounting for 52% of total mammal visits.
Short-eared Rock Wallaby	95	668	23.00	Similar occupancy but higher abundance than 2018 (23% in 2020 compared to 15% in 2018). The second most prevalent mammal species, accounting for 45 % of total mammal visits.
Rocky gorge small mammal guild	100	793	27.30	In 2020, this guild (small rodents and dasyurids) included 2 species: Common Rock Rat and Ningbing False Antechinus.

Northern Quoll

The Northern Quoll is a carnivorous, critical weight range marsupial (350-1120 g) that was once abundant and widespread across most woodland, riparian and rocky habitats of northern Australia, but has suffered significant range contraction and population decline, and is now classed as "Endangered" (Hill and Ward 2010). The primary threat to Northern Quoll is ingestion of bufotoxins in cane toads (Hill and Ward 2010), followed by other threats that affect most Australian critical weight range mammals: habitat alteration, inappropriate fire regimes, predation by feral cats, introduced herbivores, and weeds. AWC and collaborators were unsuccessful when trialing cane toad taste aversion on MMDT as the front progressed across the Kimberley, Northern Quoll populations declined, at both trial and control sites (Indigo et al. 2018).

Rocky Gorge Camera Survey

No Northern Quolls were detected on the rocky gorge array in 2020 (see Table 4).

Northern Quoll Camera Survey

Two individual quolls were detected on 3 cameras across the Sir John camera array in 2020 (i.e. occupancy: 15%; Table 5). At this site, Northern Quoll had an abundance of 4.5 detections per 100 trap nights (Table 5). This survey provides an estimate of abundance at Sir John Gorge and is repeated annually.

Table 5. Metrics for Northern Quoll from camera trap monitoring and live trapping across MMDT in 2020. Abundance = visits per 100 trap-nights. MNKA = minimum number of individuals known alive, as identified from spot patterns.

Array	Trap nights	Visits	Abundance	MNKA
Rocky Gorge Camera Survey	2900	0	0	0
Northern Quoll Camera Survey	240	11	4.5	2
Northern Quoll Live Trapping Survey	160	2	0.6	1^

^This individual was one of the two individuals detected on the Northern Quoll Camera Survey. This individual was a 4th year female.

Northern Quoll Live Trapping Survey

Over the 160 live trap-nights, one adult 4th year female Northern Quoll was captured twice at Sir John South (Table 5; Figure 13). This individual was recorded as non-breeding and in good condition, and a genetic sample was taken. The number of Northern Quolls captured during Northern Quoll Live Trapping Survey at Sir John Gorge has declined from a maximum 7.8 quolls per 100 trap-nights in 2013, to 0.6 quolls per 100 trap-nights in 2020 (Figure 13). Toads are known to have arrived at Mornington in the 2016-17 wet season and this, combined with two low rainfall wet seasons (2018-19 and 2010-20) likely accounts for the low capture rates in recent years.

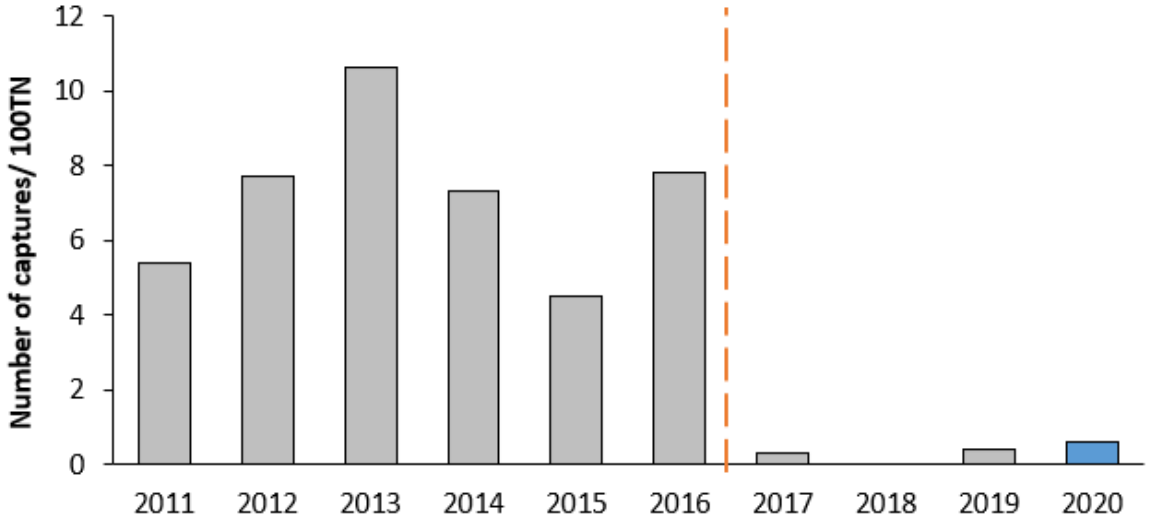

Figure 13. Abundance of Northern Quolls per 100 cage trap-nights from Northern Quoll Live Trapping Survey at Sir John Gorge north and south sites combined for 2011-2020. Orange line indicates the time that cane toads arrived at the survey area. Note that cage trapping was undertaken in various months and multiple times in some years (see Appendix 2 - Table A1), such that some of the variation in abundance may be influenced by life history and variation in quoll activity relative to timing of surveys.

Bandicoots: Northern Brown Bandicoot and Golden Bandicoot

Bandicoots are omnivorous ground-dwelling critical weight range mammals with potentially two species found on MMDT: Northern Brown and Golden bandicoots. Differentiation between these species is challenging due to overlap in size and morphological characters (AWC NW ecologists pers. comm.; Palmer et al. 2003), and consequently results for these two species are grouped as single indicator and metric. Bandicoots are best distinguished using genetic analysis of tissue samples, which is an ongoing research project in the North-west.

Bandicoot Camera Survey

Bandicoots were detected at only one of the 18 sites (eight separate detections on three cameras) in the continuous sandseep habitat east of Mt Leake Gorge in southern Mornington during the Bandicoot Camera Survey. The abundance of bandicoots at Site 1 was 0.3 visits per 100 trap-nights and the occupancy was 5.6 % of sites surveyed (Riles B 2020).

Bandicoot Live Trapping Survey

No bandicoots were caught during the live trapping at the southern Mornington sites, despite fresh diggings less than 5 m from some of the traps. During the Bandicoot Live Trapping Survey on the Phillips Range, one individual bandicoot was captured twice in the riparian strip site, giving rise to 50% occupancy (i.e. one of two sites). A genetic sample was taken, and this bandicoot was identified as Northern Brown Bandicoot with high confidence. The number of bandicoot captures per 100 cage trap-nights (abundance) was 2.8 (Figure 14). Data from bandicoot trapping should be interpreted in the context of a large fire which impacted the habitat in this refuge area in early 2020. Further monitoring over the next few seasons will be important for understanding how bandicoot abundance responds to good rainfall conditions post fire and natural habitat recovery.

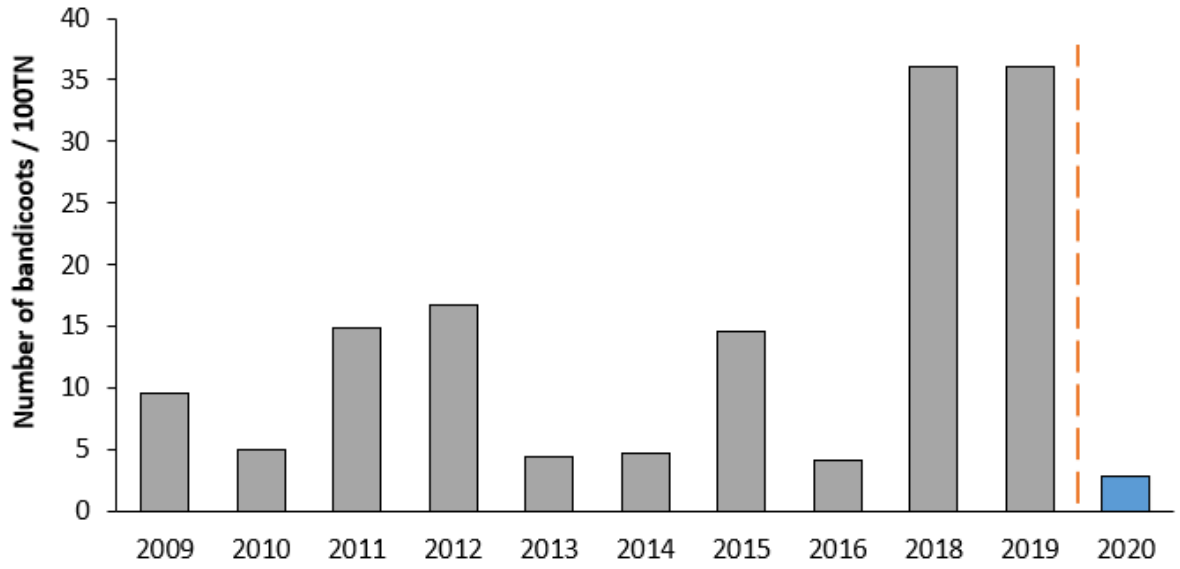

Figure 14. Abundance of individual bandicoots per 100 cage trap nights from the Bandicoot Live Trapping Survey in Phillips Range, Marion Downs, 2009-2020. Orange dashed line shows timing of fire in the survey area.

Central Pebble-mouse

At Cleanskin, a total of 43 pebble-mounds were assessed: 19 (out of 23) known from previous trips were re-discovered and 24 new mounds were found (Stockwell 2020a, 2020b). Five mounds were detected and scored at Top Bore. Across the entire 57.6 km searched a total of 48 mounds were assessed, giving rise to an esimtated density of 0.83 mounds per km searched.

Spectacled Hare-wallaby

One individual Spectacled Hare-wallaby was detected on one camera trap at Site 2 in two consecutive photos. The occupancy was 10% (Porter 2020).

Large reptiles

Cane toads pose a serious threat to populations of large predatory reptiles, including goannas and blue-tongue lizards. The impact of toads on large reptiles is particularly acute at the time of invasion, due to the

prominence of adult toads carrying a high toxin load (Shine 2010, Brown et al. 2011, Ward-Fear et al. 2016). The Kimberley supports important populations of large predatory reptiles that have declined elsewhere due to cane toads, including the Yellow-spotted Monitor, Blue-tongue Skink, Mitchell's Water Monitor and Merten's Water Monitor (Price-Rees et al. 2010; Shine 2010; Doody et al. 2015; Ward-Fear et al. 2016). Individual rock-inhabiting monitors – Black-palmed Rock Monitor, Kimberley Rock Monitor and Ridge-tailed Monitor – are susceptible to poisoning by cane toads (Smith and Phillips 2006), although the impact of cane toads on populations had not been investigated prior to the intensive survey program in southern Mornington.

The cane toad front advanced across Tableland Sancturay from 2014 to 2016 and Mornington - Marion Downs Sanctaries from 2016 to 2018. As the front approached southern Mornington, a trial mitigation program was developed to assess the viability of Conditioned Taste Aversion (CTA) as a method for reducing the impacts on Yellow-spotted Monitor, Merten's and Mitchell's Water Monitors, and Northern Blue-tongue Skink. However, the program was unable to be effectively implemented due to unprecedented rainfall (Bruton & Smith 2018, 2019). There are currently no viable methods for directly managing cane toads in the vast Kimberley landscapes.

Northern Blue-tongue Skink

Northern Blue-tongue Skinks declined dramatically from occupying 100% of the large reptile camera sites in 2016 to occupying none of the eight sites in 2018, 2019 and 2020 (Table 6). Concurrently, no Northern Blue-tongue Skinks were detected at the rocky gorge camera sites across MMDT in 2018. This suggests a considerable decline or loss of Northern Blue-tongue Skink populations from cane toad invaded sites across MMDT. However, a Northern Blue-tongue Skink was detected at one of the Rocky Gorge Camera Survey sites in 2020 (North of Paddy's Pocket, Figure 3), which confirms this species has persisted on MMDT following the establishment of cane toads. Based upon this data set, the species abundance is 0.1 individuals/100TN and it occupies 5% of rocky gorge camera sites.

Table 6. Occupancy and number of individual Northern Blue-tongue Skinks detected per year at eight Large Reptile Camera Survey (LRCS) sites in southern Mornington and Rocky Gorge Camera Survey (RGCS) sites. Arrows indicate trend from baseline (2016), to initial toad arrival (2017), and to post-toad establishment (2018 to 2020) '-' indicates site not surveyed.

Habitat	Camera Array	2016	2017	2018	2019	2020	Trend
Sandy Riverine	Bluebush	1	0	0	0	**0**	↓
	Cadjeput	1	0	0	0	**0**	↓
Small Rocky Gorge	King Boab	1	0	0	-	**0**	↓
	Bluff Pools	5	3	0	-	**0**	↓↓
	Mt Leake Gorge	2	1	0	-	**0**	↓
	Spider Gorge	1	0	0	-	**0**	↓
Seasonally Dry Escarpment	Home Range	1	2	-	0	**0**	↓
	Lady Forrest	3	0	-	0	**-**	↓
Occupancy (%) (LRCS)	**All**	**100**	**38**	**0**	**0**	**0**	**↓**
Rocky Gorge (MMDT)	Rocky gorge camera array	-	-	0	-	**1**	NA
Occupancy (%) (RGCS)	All	-	-	0	-	**5**	NA

Yellow-spotted Monitor

During the Large Reptile Camera Survey in 2020, Yellow-spotted Monitors were once again detected at both the Bluebush and Cadjeput sites, with one and two individuals detected at each site, respectively (Table 7). Overall, there is an estimtated abundance of 0.57 individuals/100TN with the species occupying 29% of sites.

Yellow-spotted Monitors were regularly detected at the two sandy riparian sites in 2016, and in 2017 as cane toads were invading the sites. The average number of indiviudal Yellow-spotted Monitors detected across 2016 and 2017 at these sandy riparian sites were 23.5 individuals (Bluebush) and 12 individuals (Cadjeput) per site (Table 7). Consistent abundance values in the first two years of monitoring (2016 and 2017) and low detectability of toads on the large reptile cameras in 2017 (see Cane Toad section of this report), mean the 2016 and 2017 Yellow-spotted Monitor population values are a robust baseline for future comparisons.

Following the arrival of cane toads, there was a significant decline in Yellow-spotted Monitor populations at both of the sandy riparian sites (Table 7). By November 2018, there was a 95% population decline at Bluebush and 100% loss at Cadjeput, and no Yellow-spotted Monitors were detected at either site in 2019 (Table 7). However, Yellow-spotted Monitors were detected at the sandy riparian monitoring sites in southern Mornington in 2020.

Yellow-spotted Monitors remain undetected at small rocky gorge and escarpment sites following the arrival of the cane toads. These sites are in suboptimal habitat and may take longer for populations to recover than sites in optimal habitat along the Fitzroy River.

Table 7. Number of individual Yellow-spotted Monitors detected per year at 8 Large Reptile Camera Survey sites in southern Mornington. Arrows indicate trend per site from baseline (2016), to initial toad arrival (2017), and to post-toad establishment (2018 to 2020). '-' indicates site not surveyed.

Habitat Type	Array	2016	2017	2018	2019	2020	Trend
Sandy Riverine	Bluebush	23	24	1	0	1	↓↓↓
	Cadjeput	13	11	0	0	2	↓↓↓
Small Rocky Gorge	King Boab	0	0	0	-	0	-
	Bluff Pools	0	0	0	-	0	-
	Mt Leake Gorge	2	1	0	-	0	↓
	Spider Gorge	1	0	0	-	0	↓
Seasonally Dry Escarpment	Home Range	3	1	-	0	0	↓↓
	Lady Forrest	0	0	-	0	-	-
Occupancy	**All**	**0.6**	**0.5**	**0.2**	**0**	**0.28**	↓

Rock monitor guild

In 2020, 80% of Large Reptile Camera Survey sites surveyed were occupied by rock monitors, with an average of 5.7 monitors detected per 100 trap-nights.

The response of rock monitors to the cane toad appears to be variable depending on species (Figure 15). There are three species occurring within this guild and none were detected in sandy riparian habitats from 2017 to 2020. Therefore, analyses and commentary are restricted to rocky habitats i.e. rocky gorges and escarpments.

The largest of the three rock monitor species, the Black-palmed Monitor, appears to have undergone a significant decline in occupancy and abundance at the Large Reptile Camera Survey sites in southern Mornington, with no detections at the five sites surveyed in 2020, compared to 67% occupancy in 2016 and 2017 (Table 8). The occupancy of Black-palmed Monitors also remains low at the Rocky Gorge Camera Survey sites across the broader toad-invaded MMDT area (2020 occupancy: 20%), and declined slightly (~7%) from 2018 to 2020 (Table 8).

The occupancy and abundance of Kimberley Rock Monitors at the Large Reptile Camera Survey sites declined from 2017 (83%) to 2019 (33%), before rebounding in 2020 at 80% of sites occupied (Table 8). These changes may be a response to extremely dry conditions during the 2017-2019 period rather than to the arrival of cane

toads. However, further monitoring is recommended to tease apart these variables, particularly at the Lady Forrest dry escarpment site where this species was abundant in 2016 (n = 9) and 2017 (n =10) but not detected in 2019. The Lady Forrest site was not surveyed in 2018 or 2020. The occupancy of Kimberley Rock Monitors was moderate and stable around 55% across the broader MMDT Rocky Gorge Camera Survey area from 2018 to 2020 (Table 8).

Populations of Ridge-tailed Monitors appear to fluctuate significantly year-to-year and from site-to-site, with no clear trends evident at this point in time (Table 8; Figure 15). There are contrasting results from the two survey programs for this species, with low occupancy (5 %) at the Rocky Gorge Camera Survey sites across MMDT in 2018 and 2020, and high and relatively consistent occupancy (2018: 50%, 2019: 60%) at the targeted Large Reptile Camera Survey in southern Mornington. The cause/s of this discrepancy are currently unclear.

Table 8. Rock monitor occupancy (%) at 8 Large Reptile Camera Survey sites ('LRCS') in southern Mornington and 20 Rocky Gorge Camera Survey sites ('RGCS') across MMDT. Arrows indicate trend from baseline (2016) to initial toad arrival (2017) and to post toad establishment (2018 to 2020).

Species / group	Survey	2016	2017	2018/19*	2020	Trend
Rock monitor guild (All species)	LRCS RGCS	100	100	50 66	**80** **60**	↓
Black-palmed Monitor	LRCS RGCS	67	67	16 27	**0** **20**	↓↓
Kimberley Rock Monitor	LRCS RGCS	100	83	33 58	**80** **55**	↓
Ridge-tailed Monitor	LRCS RGCS	83	67	50 5	**60** **5**	↓

*For the Large Reptile Camera Survey, only rocky gorge and sandy riparian sites were surveyed in 2018 and only seasonally dry escarpment sites and sandy riparian sites were surveyed in 2019. The "2018/19" metric is a combination of both 2018 and 2019 for these surveys due to the split of sites and effort over the two years, and thus it represents a more complete effort (n=10). The values presented for the Rocky Gorge Camera Survey are for 2018 only. Rocky Gorge Camera Surveys only conducted in 2018 and 2020.

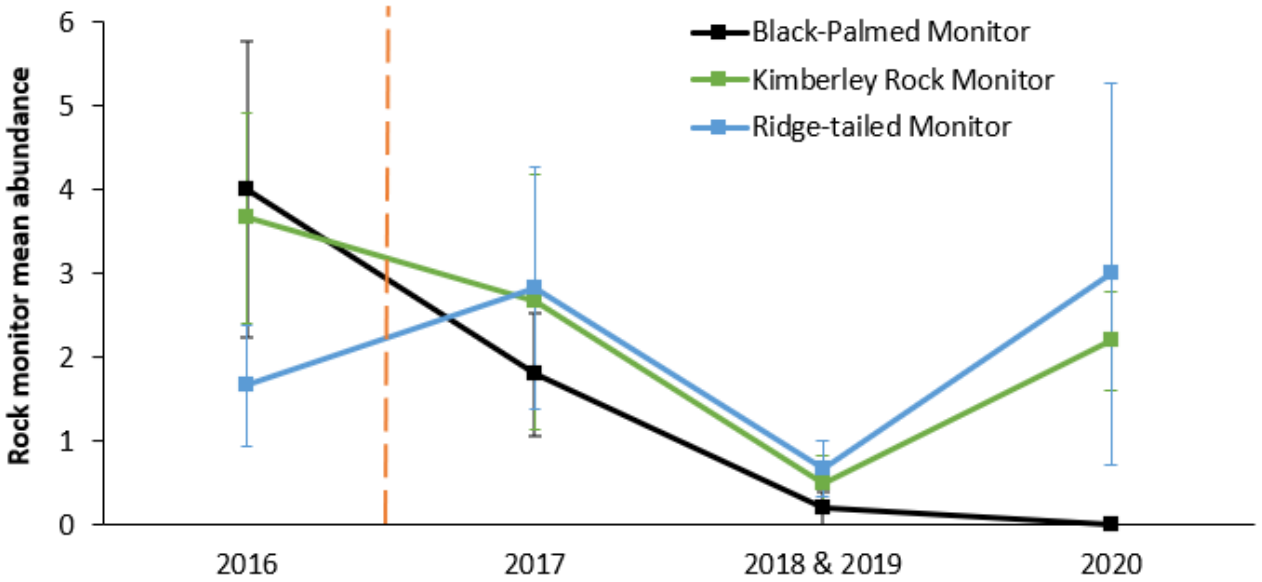

Figure 15. Mean abundance (average number of individuals detected per year) of rock monitors across all small rocky gorge (n = 4) and seasonally dry escarpment (n = 2) sites for the Large Reptile Camera Survey program in Southern Mornington from 2016 (pre-toad), to initial toad arrival in 2017 (orange dashed line), and to post-toad establishment (2018 to 2020). Error bars indicate standard error. The '2018 & 2019' value is a combination of both years, with the small rocky gorge sites surveyed in 2018 only, and the seasonally dry escarpment sites surveyed in 2019 only.

Water monitor guild

Two speciecs known to occur on MMDT form the water monitor guild; Mitchell's Water Monitor and Merten's Water Monitor. In 2020, two individual Merten's Water Monitors were detected at the King Boab site, the first dectection of this species at this site since 2016. There were no other detections of either species during 2020 surveys on MMDT.

The impact of cane toads on water monitors was suspected to be significant, based on recorded impacts to both Mitchell's and Merter's Water Monitors populations in the Northern Territory and Queensland (Doody et al. 2015). However, neither water monitor species was detected with sufficient regularity at a monitoring site prior to the arrival of cane toads for robust baseline comparisons (Table 9). As such, the values reported here represent values for long-term monitoring at sandy riparian and small rocky gorge sites, without comparison to pre-toad values. Water monitors have not been detected during the rocky gorge camera survey program across MMDT.

Table 9. Occupancy and number of individual water monitors detected at the 8 Large Reptile Camera Survey sites on southern Mornington from 2016 to 2020. '-' indicates site not surveyed.

Habitat	Sites	Species*	2016	2017	2018	2019	2020
Sandy Riparian	Bluebush	Me	0	0	0	0	0
		Mi	0	0	0	0	0
	Cadjeput	Me	2	2	1	0	0
		Mi	1	0	0	0	0
Small Rocky Gorge	King Boab	Me	5	0	0	-	2
		Mi	0	0	0		0
	Bluff Pools	Me	0	0	0	-	0
		Mi	0	0	0		0
	Mt Leake Gorge	Me	0	0	0	-	0
		Mi	1	1	0		0
	Spider Gorge	Me	0	4	0	-	0
		Mi	0	0	0		0
Seasonally Dry Escarpment	Home Range	Me	0	0	0	0	0
		Mi	0	0	0	0	0
	Lady Forrest	Me	2	2	1	0	-
		Mi	1	0	0	0	
Occupancy	**All**	**Me**	**0.4**	**0.4**	**0.2**	**0**	**0.1**
		Mi	**0.4**	**0.1**	**0**	**0**	**0**

* Me = Merten's Water Monitor, Mi = Mitchell's Water Monitor.

Freshwater Crocodiles

The impact of cane toads on Freshwater Crocodile populations in northern Australia is known to vary with location and habitat (Letnic et al. 2008; Doody et al. 2009; Somaweera et al. 2012, 2019). There is some evidence to suggest that crocodiles are more susceptible to poisoning in drier regions and habitats, due to the congregation of toads in the few suitable waterbodies available, and therefore a greater likelihood of interaction (Letnic et al. 2008).

There are currently no viable methods for directly managing cane toads in remote Kimberley waterways. In 2016 and 2017, a Freshwater Crocodile toad mitigation program using Conditioned Taste Aversion baits was trialled at Windjana Gorge (Ruchira Somaweera pers. comm.), based on the outcomes of Somaweera at al. (2011) and the successful field trials of CTA on goannas in the Kimberley (Ward-Fear et al. 2016). This program proved unfeasible at a large scale.

Following the arrival of cane toads in 2017, the mean density of Freshwater Crocodiles has declined by approximately 50 % from a mean of 23.1 (2016) to 12.0 (2020) individuals sighted per kilometre of waterway surveyed (Figure 16). These results correlate with similar findings in the Daly River, Northern Territory, where a 77% population reduction was observed following the arrival of cane toads (Letnic et al. 2008). This change in density is most marked in the sandy riparian habitats of the Fitzroy River, where 14.9 fewer crocodiles were detected per kilometre in 2020 compared to 2016.

Larger Freshwater Crocodiles appear to be the size class most affected by cane toads on MMDT, with the most notable declines evident in the 3-5 foot size range. This also correlates with observations in the Daly River, NT where 2-5 foot crocodiles were most likely to die from ingesting a toad (Letnic et al. 2008).

In 2020, there was a notable increase in the density of 1-2 foot crocodiles detected in rocky habitats. Many species of crocodilians are known to cannibalise smaller individuals (see Cedeño-Vázquez 2016 for review), including Freshwater Crocodiles (Australian Museum 2020). Also, the hatchling success of Freshwater Crocodiles is known to increase significantly following the cane toad invasion, due to reduced nest predation by monitors (Webb and Manolis 2010). This suggests that the increase in 1-2 foot Freshwater Crocodiles in rocky habitats is likely due to reduced predation pressure on hatchlings and small crocodiles by large crocodiles and monitor lizards, which have both declined significantly in the area following the arrival of the cane toad (Figure 16, NWET 2020). At this stage it is unclear why the increase in small Freshwater Crocodile density is only evident in the rocky gorge habitats, and also if it will translate to a population recovery in these areas over time.

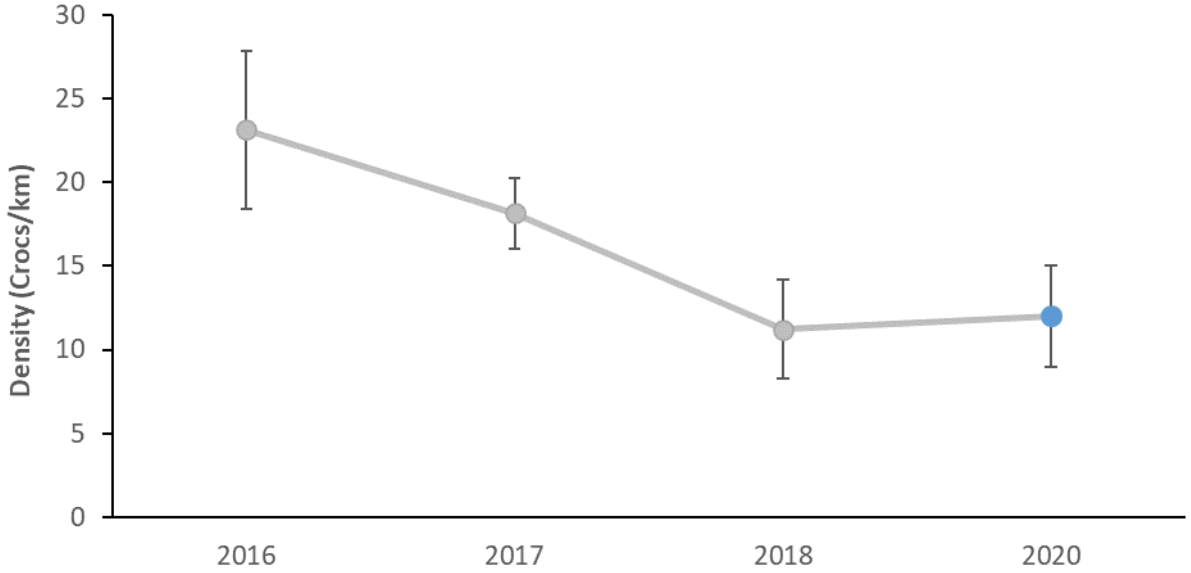

Figure 16. Change in Freshwater Crocodile density between 2016 and 2020 as an average of all sites. Surveys were not conducted in 2019. Error bars represent standard error.

Birds

Riparian birds

Purple-crowned Fairywren

The Purple-crowned Fairywren is an insectivorous, socially intricate bird, restricted to riparian habitat with a dense intact middle storey of Pandanus and a shady canopy of emergent trees (Skroblin and Legge 2012). The western subspecies is found along tropical creeklines and rivers of the Kimberley region and is nationally listed as “Endangered” (EPBC 1999) due to ongoing population decline (Birdlife International 2016). This is largely a result of habitat degradation from altered fire regimes (Woinarski 1990), weed invasion and introduced herbivores (McKenzie et al. 2009). Due to the strong connection between intact riparian environments and their abundance and distribution, Purple-crowned Fairywrens are considered a good indicator of riparian health (Skroblin and Legge 2012). Populations of wrens have been monitored at Mornington Wildlife Sanctuary since 2005, a year after these habitats were de-stocked of feral herbivores.

In 2020, the end-of-year census identified 143 birds across 53 territories within the focal area, slightly higher than the mid-year census of 127 birds across 57 territories. The data show that the population of Purple-crowned Fairywrens in the Annie Creek - south Adcock focal area increased steadily from 2005 – 2017, with a small decline in 2018 and a substantial decline in 2019. Numbers currently appear to be stabilising (Figure 17**;** Table 10).

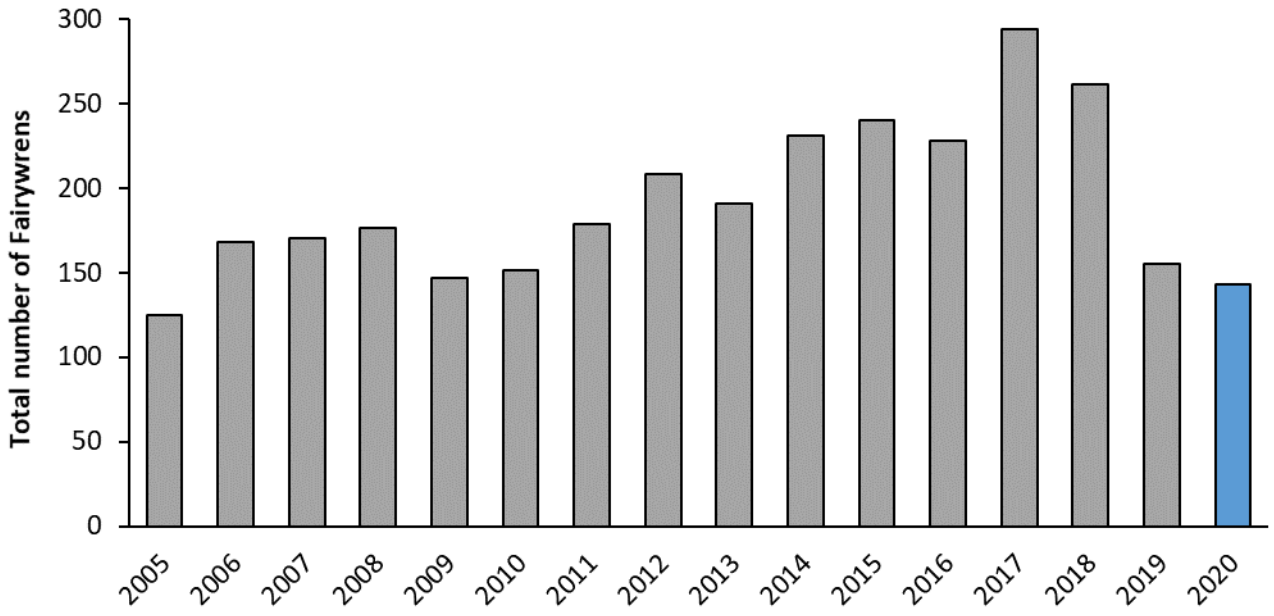

Figure 17. Population estimate (total number of inviduals) of Purple-crowned Fairywrens from 2005-2020 in the focus area (Annie Creek and south Adcock) on Mornington. Birds are censused in June and November each year by researchers from Monash University. Values from November are presented here.

Fairywren density (the number of birds per km) within the focus area was lowest in June 2020 (8.6 birds per km) and increased slightly in November 2020 (9.7 birds; Table 10). In contrast, the number of fairywren territories continued to decline from 2019 and earlier with 57 territories in June 2020 and 53 in November 2020 (Table 10). The number of fairywren territories is considered a strong indicator of riparian health, as the size of a territory depends greatly on habitat quality. With more resources, a higher number of groups can live in an area. The observed decline in territories between 2019 and 2020 can be attributed to both an overall population decline, as well as, an increased size in remaining territories due to reduced resources. The trends are interpreted as the result of unusually dry conditions in both the 2018 and 2019, compounded by the effects of a fire that damaged parts of the focus area in March 2019, which reduced habitat and resource availability within the focus area, and hence the fairywren population, density and number of territories. The slight increase in fairywren density observed at the end of 2020 may be an early indication of population rise with increased breeding activity in the leadup to the 2020-21 wet season.

Table 10. Metrics for Purple-crowned Fairywren in the focus area (Annie Creek and south Adcock) on Mornington for 2019 and 2020 from the census conducted by researchers from Monash University twice annually (June and November). Density = number of birds per kilometre.

Metric	2019		2020	
	June	November	June	November
Population Estimate	212	155	127	143
Density	14.3	10.5	8.6	9.7
Number of territories	73	67	57	53

Nocturnal birds

Nocturnal birds - guild

Nocturnal predatory bird species may be declining due to the loss of small mammal prey from northern savannas (TSSC 2015). Changes in the populations of nocturnal birds may provide an indication of ecological health on MMDT in relation to small mammals. Additionally, the impact of fire regimes on invertebrate prey availability for nocturnal birds in northern Australia is not known and may impact species that primarily feed on invertebrates and insects.

During the two trial spotlight surveys on Marion Downs in 2020, three nocturnal bird species were positively identified (Spotted Nightjar, Tawny Frogmouth and Australian Owlet-nightjar) and there were two sightings of unidentified night birds. All nocturnal bird species detected were primarily insectivorous (rather than mammal-eating predators). The mean detection rate was 3.5 birds per 30 km survey at a density of 0.11 birds per km.

The low detection rates and repeatability between each spotlight transect indicates that this survey method requires further development before being implemented into Ecohealth monitoring. Seven nocturnal bird species known to occur on MMDT were not detected in 2020 trials, including Barking Owl, Southern Boobook, Eastern Barn Owl, Eastern Grass Owl, Rufous Owl, Masked Owl and Bush Stone-curlew.

Threat metrics

Feral herbivores

Large introduced herbivores such as cattle, horses and donkeys are distributed over northern Australia and cause major damage to ecosystems significantly altering biotic interactions (Woinarski and Ash 2002, Legge et al. 2011). At a landscape scale, feral herbivores can greatly reduce habitat availability, particularly in the ground layer (Legge et al. 2015), and interact with other major threatening processes, such as fire, to further effect biodiversity (Legge et al. 2019).

Cattle

In 2020, during the aerial survey, approximately 65% of cattle observed were within the 45° angle observation area (200 m transect width under flight path), indicating a steep drop in detection probability with distances greater than 100 m. Within 2 km of water, a total of 120, 270 and 208 head of cattle were observed on 2020 surveys across Mornington, Marion Downs Sanctuaries and Tableland Partnership Area, respectively (Table 11). Across MMDT, the density of cattle within 2 km of water was 5.7 head/km^2, with 2.9, 8.2 and 6.7 head/km^2 on Mornington, Marion Downs Sanctuaries and Tableland Partnership Area, respectively (Table 11). Cattle densities greater than 2 km from water were much lower at 0.27 head/km^2 across MMDT. Controlling for pastoral productivity and distance to water, the total estimate of cattle is 16,270 head on MMDT, which includes 3,193 on Mornington, 6,097 on Marion Downs, and 6,980 on Tableland (Table 11). Comparison of the results with previous years is difficult due to significant changes to the methodology and analysis in 2020. These data will be used to target 2021 cattle management for key areas of ecological value.

Table 11. The total number of cattle observed, measured density (cattle/km^2) and cattle estimates within 2 km of water across MMDT on each property separately and overall, in 2020. An overall estimate of total cattle numbers on each property separately and overall is based on extrapolations from flown survey data.

Sanctuary	Total cattle observed	Measured Density (cattle/km^2)	Cattle estimate (<2 km from water)	Total cattle estimate
Mornington	120	2.87	3,100	**3,193**
Marion Downs	270	8.19	5,920	**6,097**
Tableland	208	6.74	6,776	**6,980**
MMDT	**598**	**5.66**	**15,796**	**16,270**

Horse and Donkey

A total of 4 donkeys and 15 horses were observed during 886 km of feral herbivore surveys across MMDT. This equates to a rough density estimate of 0.45 donkeys and 1.7 horses per km^2.

Other threats

Cane toads

The cane toad poses as serious threat to populations of large native predatory reptiles and mammals. The impact of toads on these taxa is particularly acute at the time of invasion, due to the presence of adult toads carrying a high toxin load (Shine 2010; Brown et al. 2011; Ward-fear et al. 2016). The cane toad front

advanced across Tableland (2014-2016) and Mornington-Marion Downs (2016-2018) and was monitored by AWC during this period. The abundance or occupancy of toads can be compared with changes in susceptible species populations for a better understanding about the underlying interactions and impacts of toads on native predators.

Across MMDT, the estimated occupancy of cane toads at survey sites and camera arrays shows annual variation in relation to rainfall in the previous wet season, habitat and location of the cane toad front. In 2020, cane toad occupancy was calculated from Rocky Gorge and Large Reptile Camera Surveys only as no Standard Live Trapping was undertaken in 2020.

Rock Gorge Camera Survey
The MMDT Rocky Gorge Camera Surveys were first surveyed in 2018, and again in 2020. The estimated occupancy of cane toads at the MMDT Rocky Gorge Camera Survey sites decreased from 2018 to 2020 (Table 12). Toads were not recorded from Cleanskin East, North of Cleanskin, South of Cleanskin, Phillips Range East, Cowendyne Creek, West of King Boab,Warton Range, and Mt Leake.

Large Reptile Camera Survey
Cane toads were first recorded on the large reptile camera arrays in January 2017. The occupancy of cane toads on the large reptile cameras increased from 2017 to 2018, declined during dry conditions in 2019, then increased again to a 86% of survey locations occupied in 2020 (Table 12).

Table 12. Occupancy of cane toads at survey sites on MMDT.

Survey Method	2016	2017	2018	2019	2020
Rocky Gorge Camera Survey (MMDT)	-	-	89%	-	60%
Large Reptile Camera Survey (Mornington)	nil	88%	100%	50%	86%

*For the Large Reptile Camera Survey, only rocky gorge and sandy riverine (n=6) sites were surveyed in 2018 and seasonally dry escarpment and sandy riverine sites (n=4) were surveyed in 2019.

Fire

Destructive fire regimes characterised by frequent and extensive late dry-season fires are a critical threatening process for a wide range of taxa in northern Australia (Woinarski et al. 2011). Therefore, management of fire regimes is the primary conservation tool available at the landscape scale in the Kimberley.

AWC manages fire regimes through a combination of planned early dry-season burning (both aerial and road-based) and where needed, late dry-season suppression. The primary goals of management are to create a fine-scale mosaic of burn scars and vegetation ages across the landscape, reduce the extent burnt by late-dry season fires, and reduce fire impacts on fire-sensitive species.

The unusually dry 2019-2020 wet season led to a very early curing of grasses and drying out of fuel across MMDT. The drier grass, and low-humidity nights meant that prescribed fires were no longer self-extinguishing overnight, and were difficult to supress if needed. One such fire caused considerable damage to a rainforest and sandstone refugial area at lower the Phillips Range – important habitat for Savannah Gliders, Bandicoots and a potential assemblage of north west range-restricted endemic herpetofauna. The decision was therefore made to cease the prescribed burning program earlier than planned in 2020. Nevertheless, in total, 7,235 km of aerial control burning was completed, resulting in 14% of MMDT being burned in early-season fires (Table 13). The burn months are displayed in Figure 18. The annual Fire Analysis Reports contain a more detailed analysis and report on the following metrics (e.g. Cooper et al. 2020).

Table 13. EcoHealth metrics for fire management on MMDT, showing results for 2020, averages under AWC management, and baseline averages prior to AWC management.

Metric	Baseline 2000/2002-2006	AWC management 2008/2010-2020	2020 result	Change since AWC management
Area burnt by early dry season fire (% of property)	12	18	14	↑
Area burnt by late dry season (LDS) fire (% of property)	25	10	0.1	↓
Cumulative percent of sanctuary burnt by LDS fire in previous three years	52	29	21	↓
Mean distance to unburnt vegetation (km)	1.5	0.8	0.4	↓
Mean distance to vegetation unburnt by LDS fire for three or more years (km)	2.3	1.1	0.9	↓

Baseline values for metrics are the average for the years immediately prior to management of Mornington-Marion Downs and Tableland: i.e., 2000-2006, for annual metrics, and 2002-2006, for 3 year metrics

AWC management values for metrics are the average for the years following management of Mornington-Marion Downs and Tableland by AWC: i.e., 2008 onwards, for annual metrics, and 2010 onwards, for 3 year metrics

Change since AWC management: change in metric, AWC management compared with baseline, based on statistical analysis (see report) (increase ↑, no change ↔, reduction ↓). Inferred consequences for ecological health are depicted by colour: improving in green (e.g., ↑ or ↓, depending on the metric); deteriorating in red (e.g., ↑ or ↓); no change, or if the change cannot be interpreted in terms of ecological health, in black. (↔, ↑ or ↓).

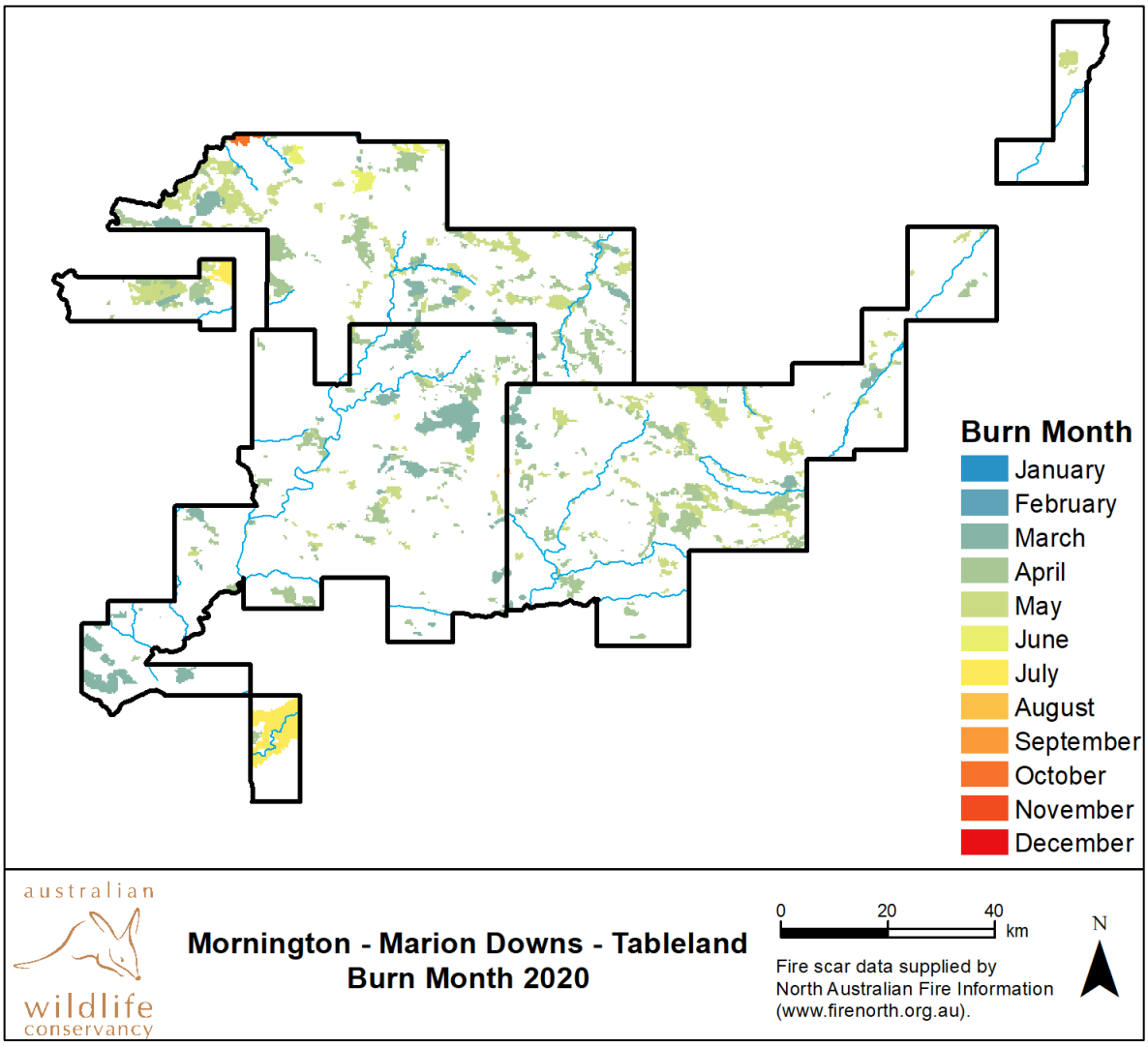

Figure 18. Fire scars by month on MMDT in 2020.

Discussion

This MMDT Ecohealth Report summarises the results of the 2020 surveys conducted under the Ecohealth Monitoring Program. A considerable survey effort of annual monitoring (11,129 camera trap-nights, 385 live-trap nights, 66 km of spotlight transects and 886 km of aerial surveys, as well as, extensive targeted surveys) was undertaken despite the restrictions associated with Covid-19 and an early onset of the 2020-21 wet season. Where available, results from surveys conducted in previous years (2004-2019) provided baseline numbers for comparison. In some cases, 2020 is the first survey year, for others, methods are still in development. For these indicators, it is difficult to comment on current trends in metrics.

Small-medium sized mammals showed varying trends in abundance and occupancy, however most significant result was that no Northern Quolls were detected in the rocky-gorge camera survey, and only one quoll was detected in the targeted monitoring program at Sir John Gorge. The decline of Northern Quolls on MMDT follows the arrival of cane toads in 2016-17, consistent with trends observed elsewhere for this species. An intensive Northern Quoll survey will be conducted in 2021 at all historic quoll detection sites across MMDT, to clarify the conservation status of this species on MMDT, and to inform future interventions.

Large reptiles have also declined following the arrival of cane toads on MMDT. However, data from the large reptile surveys showed a very slight increase in the number of Yellow-spotted Monitor, Kimberley Rock Monitor, Ridge-tailed Monitor and Freshwater Crocodiles in 2020, compared with the previous year. Further monitoring in coming years will be crucial for determining whether this trend continues, perhaps indicating the start of population recovery. Populations may recover if there is natural selection for individuals that do not eat toads or are otherwise resilient to their invasion, or if toad invasion knocks out competitors or predators of particular species.

Additional fauna surveys were trialled in 2020 including surveys targeting the Central Pebble-mouse and Spectacled Hare-wallaby. The cryptic nature and/ or low numbers of these species may not allow for collection of sufficient data for meaniful analysis of long-term trends.

Below-average rainfall in the 2019-20 wet season (551 mm), which followed one of the driest wet seasons on record in 2018-19 (404 mm), is hypothesised to be a key variable explaining some of the negative trends in abundance and occupancy observed across many taxa in 2020. In particular, the population estimate for Purple-crowned Fairy-wren has declined by 55% since the 2018-19 wet season. Fairywrens were also affected by a fire occurring in a proportion of the intensive study area in 2019. Encouragingly, in the late dry of 2020, Purple-crowned Fairy-wrens were breeding out of season, which may drive an increase in population in 2021.

Knowledge of the impacts of, and interactions between, key threatening processes such as fire, feral herbivores and cat predation is a key driver behind land management across MMDT. A new survey method for aerial herbivore surveys was implemented in 2020, producing an estimate of 16,270 head of cattle across MMDT, much higher than anticipated. Data from these surveys will help AWC review the feral herbivore strategy for MMDT.

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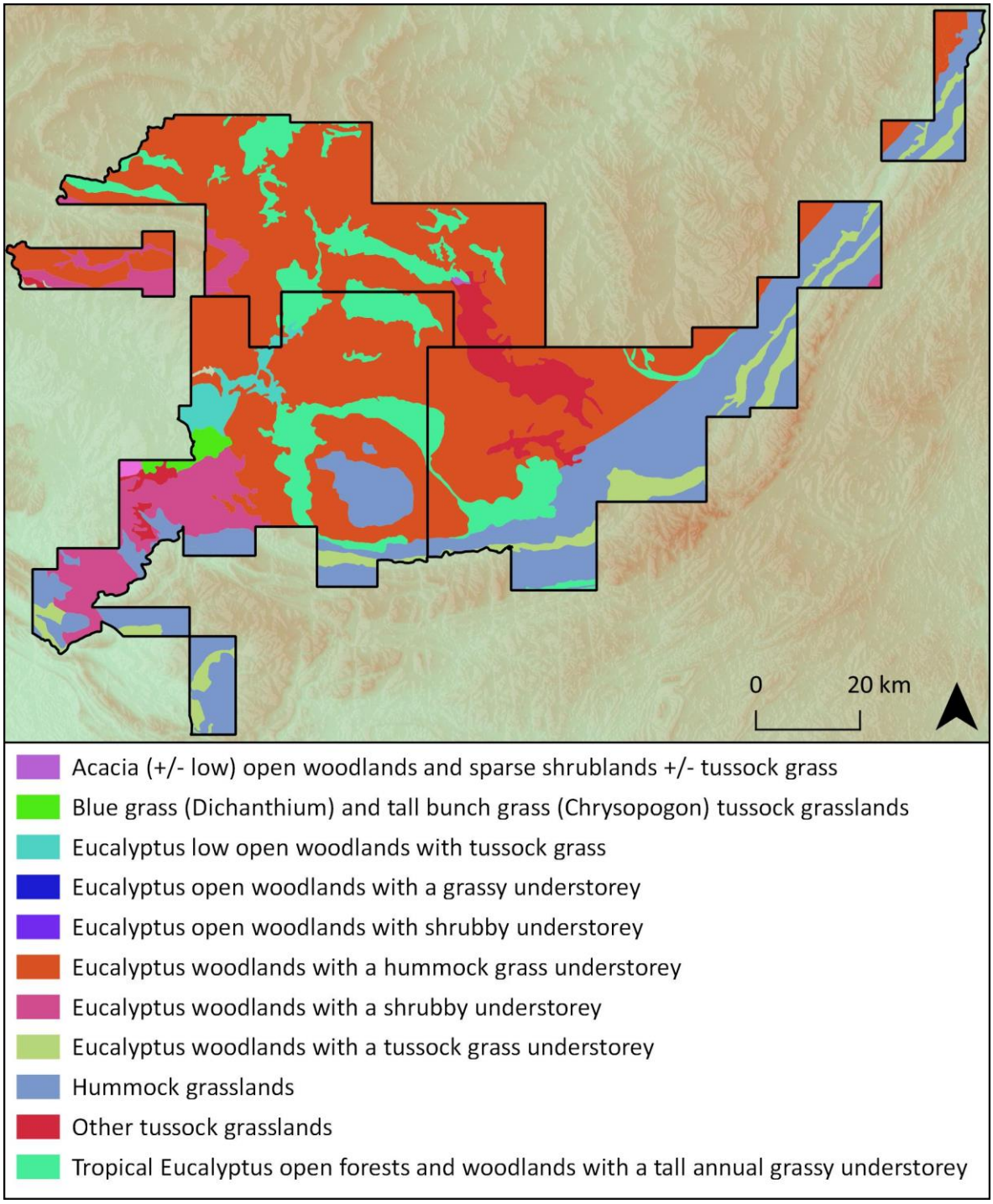
Appendices

Appendix 1: Vegetation classifications



Vegetation extents and descriptions modified from the National Vegetation Information System (NVIS) Version 5.1 (2018), obtained from the Department of Agriculture, Water and the Environment. Descriptions given are 'Major Vegetation Subgroups' as mapped.

Appendix 2: Survey methods

Targeted surveys

Northern Quoll

Northern Quoll Live Trapping Survey

Northern Quoll live trapping has historically been conducted at Sir John Gorge for monitoring and research, including inventory, trials using detection dogs, radio tracking and cane toad aversion training (Indigo et al. 2018). This report will focus on the results of live trapping for Northern Quoll population monitoring only. Total trap effort for Northern Quoll monitoring from 2011-2020 is 5,476 trap-nights, with a breakdown by year and month shown in **Appendix 2 – Table A1**.

Table A1: Trap effort for live trapping to monitor Northern Quoll populations in Sir John Gorge on the north and south sides of the Fitzroy River between 2011 and 2020.

Year	Month	Effort		Total effort
		North	South	
2011	February	46	0	46
	April	80	0	80
	June	60	0	60
	August	240	0	240
	October	80	40	120
	December	270	0	270
2012	February	66	32	98
	April	87	84	171
	July	216	38	158
	September	150	160	310
	November	120	0	120
2013	March	168	90	278
	June	198	30	228
	September	180	30	210
2014	January	124	0	124
	March	171	90	261
	June	180	90	270
	October	156	90	246
2015	April	172	120	292
	June	180	90	270
	October	210	90	300
2016	April	80	48	128
	July	64	64	128
2017	May	160	140	300
2018	*No live quoll trapping for population monitoring was undertaken in 2018*			
2019	July	368	320	688
2020	July	40	40	80

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